SUPPORTING DOCUMENT FOR BACKGROUND CONTEXT AND INFORMATION ONLY:

Hinkley Point C Development Site

Environmental Statement – Volume 2 (October 2011)

Chapter 19 – Marine Ecology

(Appendices to Chapter 19 can be found on the Hinkley Point C New Nuclear Power Station page of the National Infrastructure Planning Website: infrastructure.planninginspectorate.gov.uk/projects/south-west/Hinkley-point-c-new-nuclear-power-station)

Hinkley Point C | Development Consent Order Application

Environmental Statement
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Environmental Statement - Volume 2

Hinkley Point C Development Site

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CHAPTER 19: MARINE ECOLOGY

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19. MARINE ECOLOGY

19.1 Introduction

a) Introduction

19.1.1 This chapter of the Environmental Assessment (ES) assesses the potential impacts of the construction and operational phases of Hinkley Point C (HPC) on marine ecosystems at Hinkley Point and, where appropriate, the wider Bridgwater Bay and Inner Bristol Channel environment. Details of these phases are provided in **Volume 2**, **Chapters 2, 3** and **4**.

19.1.2 The assessment of potential impacts has been undertaken in accordance with the methodology outlined in **Volume 1**, **Chapter 7**. Available published data and grey literature have been examined, which includes data derived from ongoing impingement and entrainment sampling at Hinkley Point B (HPB) intake screens. To secure the marine science base to support consideration of this development, both in terms of environmental assessment and appropriate engineering design, a range of investigations were instigated by British Energy under the umbrella of the British Energy Estuarine and Marine Studies (BEEMS) process, subsequently adopted by EDF Energy. These investigations were designed to gather baseline data across appropriate temporal and spatial scales for the key ecological components of the surrounding ecosystems.

19.1.3 Following initial assessment, if an impact has the potential to be of moderate adverse significance or greater, where possible, mitigation measures have been identified to reduce predicted impacts. In some instances, mitigation measures are an integral aspect of the initial project design (e.g. the temporary aggregate jetty design or the cooling water outfall location).

b) Study Area

19.1.4 The geographical extent of the area of interest for the marine ecological assessment is principally determined by the potential zone of effect, and especially the mixing zone (i.e. the area in which the initial dilution of a discharge occurs). Particularly sensitive habitats or species that have conservation or commercial status in adjacent areas have also been considered.

19.1.5 The extent of dedicated survey and assessment effort has also been dependent upon an understanding of the highly dynamic physical processes that govern the ecology of the Inner Bristol Channel (see **Volume 2**, **Chapter 17**).

19.1.6 For the purpose of descriptions in this chapter, the HPC Development Site is located on a rocky section of the southern shore of the Inner Bristol Channel, and marks the western limit of Bridgwater Bay, itself bound to the north and east by the promontory of Brean Down. Within Bridgwater Bay, a substantial intertidal area is split into two parts by the estuarine channel of the River Parrett, with Stert Flats and the outer Gore Sands to the south and Berrow Flats to the north. The Inner Bristol Channel extends from a line between Hurlestone Point (west of Minehead, Somerset) and

Nash Point (Glamorgan) to the west, and Brean Down (Somerset) and Lavernock Point (Glamorgan) to the east, upstream of which lies the Severn Estuary. The Bristol Channel as a whole is taken to extend as far seaward as a line running approximately between Hartland Point on the Cornish coast and Old Castle Head on the Pembrokeshire coast.

19.1.7 The HPC Development Site is located within and adjacent to a number of national and international conservation designations that cover a range of marine ecological interests (see **Figure 19.1**). These designations and the species and habitats for which they are designated have been of prime consideration for the assessment process. Ecological receptors with protected status have been identified. Where a species or habitat is of conservation or general ecological importance, but does not have protected status, it has also been discussed in more detail. Where a species is fished commercially or has been subject to similar scrutiny, potential impacts have been assessed in relation to understandings of the size of the population involved.

c) Scope of Assessment

19.1.8 To identify the scope of the issues to be covered in the assessment, an initial evaluation of the potential for interactions between defined project activities and the receiving environment was undertaken. This resulted in a number of activities being identified which have the potential, on the basis of likelihood and the known response of the ecological parameters, to cause interactions/effects. These interactions are identified and listed in **Table 19.1**. The table does not provide an exhaustive list of potential interactions, but solely those for which further assessment work was considered necessary.

Table 19.1: Marine Ecology - Sources of Potential Interactions with Defined Project Activities for a Range of Key Receptors

Receptor	Phytoplankton	Zooplankton	Epifauna	Benthic flora	Subtidal invertebrates	Intertidal habitats (including *Sabellaria*)	Fish	Marine mammals
Construction								
Physical damage to habitats (e.g. construction on the seabed, dredging etc.)			✓	✓	✓	✓	✓	
Disturbance to habitats and species			✓	✓	✓	✓	✓	✓
Changes in water quality	✓	✓	✓	✓	✓	✓	✓	✓
Noise impacts (piling and vessels)			✓				✓	✓

Receptor	Phytoplankton	Zooplankton	Epifauna	Benthic flora	Subtidal invertebrates	Intertidal habitats (including *Sabellaria*)	Fish	Marine mammals
Operation								
Loss or change in habitat caused by presence of structures			✓	✓	✓	✓	✓	✓
Entrainment and impingement impacts on intake screens	✓	✓	✓	✓	✓		✓	
Water quality - temperature, flow and chemical impacts from thermal plume	✓	✓	✓	✓	✓	✓	✓	✓
Water quality - chemical discharges	✓	✓	✓	✓	✓	✓	✓	✓
Maintenance dredging			✓	✓	✓	✓	✓	✓
Noise impacts from maintenance vessels			✓				✓	✓

19.1.9 There is a potential for a period of overlapping generation involving both HPB and HPC, relevant to this assessment. The assessment methodologies applied within this chapter reflect this understanding.

19.1.10 The potential effects of climate change on certain species and populations are touched upon but no attempt is made by this ES to predict the level of change that might occur to the mix of species that are found in the marine and estuarine waters around Hinkley over the life of HPC.

d) Consultation with Regulatory Bodies

19.1.11 Consultation in relation to marine ecological interests has been undertaken with various stakeholders throughout the development of the project. Further information may be found in the **Consultation Report**. A summary of the key meetings at which the scope of the assessment work has been discussed is provided in **Table 19.2**.

19.1.12 This summary does not represent a full account of all meetings held, only those where marine ecology and other marine issues relevant to the assessment process were discussed.

Table 19.2: Summary of Consultation Meetings Undertaken to Determine Scope and Nature of Marine Ecological Assessment and Survey Work

Date	Attendees	Consultee Discussion/Comments
20/08/08	Natural England (NE), Environment Agency and Countryside Council for Wales (CCW)	Marine ecology issues discussed – some gaps identified in initial data review. Coastal processes and coastal protection also discussed. Possible need for offshore surveys identified. Fisheries data to be requested from CCW, identification of coastal workshop attendees required, methods for offshore surveys to be discussed with NE. Such gaps in provision of data were subsequently corrected by assimilation of BEEMS programme. Environment Agency identified a lack of sufficiently detailed water quality data: see **Volume 2, Chapter 18**. Also discussed coastal monitoring and defence issues and management of discharges.
22/09/08	CCW Correspondence	Water dependent features within the assessment area should be detailed as previously suggested in consultation.
03/11/08	NE	Terrestrial ecology and marine ecology scoping meeting with the purpose to discuss and agree scope of proposed surveys. The proposed sampling design for the local scale surveys was presented at this meeting. NE confirmed it was content with range and scope of proposed surveys, but requested that a full 12 month survey period was applied for certain key species, specifically fish. It was discussed that shad (protected Annex II species under the EC Habitats Directive (92/43/EEC), see Section 19.3) abundance tends to peak in July/August and therefore likelihood of catching this species increases during these months so sampling was extended to cover this period.
16/01/09	NE and CCW	CCW comments on marine ecology methodology were received on 09/02/09. NE comments on marine ecology were received on 12/02/09. Other than extension of surveys as decided at the 03/11/08 meeting no other changes to survey design were requested.
11/03/09	CCW, NE, Environment Agency and Sedgemoor District Council (DC)	Marine Authorities Liaison Group Meeting was held to discuss consents and estuary issues.
24/06/09	Environment Agency, Royal Haskoning, NE, Somerset County Council, Marine and Fisheries Agency and West Somerset Council	Meeting held to discuss Marine Authorities. Discussed offshore investigations, shore access arrangements and Sea Protection Group. Also discussed, water abstraction and discharge, soil, groundwater and ground gas, surface and marine water.
28/07/09	Environment Agency, Marine Fisheries Agency, English Heritage, West Somerset Council, Somerset County Council, ARUP	Status presentation on studies regarding shore access, sea protection wall, abstraction and discharge, water quality, contaminated land, groundwater, ground gas.

19.2 Legislation and Policy

19.2.1 In the context of marine ecology, this section describes the main legislative and planning policy considerations in relation to the proposed development. Such legislation and policy provides controls on the types of development which can be conducted within the marine environment and sets out the measures and processes that should be implemented to protect designated sites and biodiversity interests.

a) Legislation and Policies Relevant to the Marine Biodiversity and Conservation Interests of the Study Area

i. International Conventions

The Ramsar Convention of Wetlands of International Importance 1971

19.2.2 The Ramsar Convention provides the framework for national action and international co-operation for the conservation and considerate use of wetlands and their resources. Suitable wetlands are designated for inclusion in the List of Wetlands of International Importance. In order to promote the conservation of Ramsar sites, the UK implements the Convention through the Sites of Special Scientific Interest (SSSI) system, with some overlap with Special Area of Conservation (SAC) and Special Protection Area (SPA) sites (see paragraphs 19.5.8 to 19.5.10 on EC Birds Directive and Habitats Directive). The Ramsar Policy Statement 2000 offers Ramsar Sites equivalent protection to Natura 2000 sites. Of relevance to the proposed development is the Severn Estuary Ramsar designation.

19.2.3 The Severn Estuary Ramsar site is designated due to a combination of a number of attributes including; the large tidal range, presence of Annex I habitats protected under the Habitats Directive (see paragraphs 19.5.11 to 19.5.13 for Habitats Directive), the presence of unusual estuarine communities (reduced diversity and high productivity), the run of migratory fish between the sea and river via the Severn Estuary, the fish of the whole estuarine and river system (which is one of the most diverse in Britain) and wildfowl and wader assemblages and species/populations of international importance. The Bridgwater Bay National Nature Reserve (NNR) is also designated a wetland of international importance under the Ramsar Convention.

The Convention on Biological Diversity 1992

19.2.4 This Convention focuses on the conservation of all species and ecosystems and therefore provides protection to all biodiversity. The Convention requires the development of national strategies, plans or programmes for the conservation and sustainable use of biodiversity. In accordance with this, the UK has developed Biodiversity Action Plans (BAPs). For intertidal and subtidal zones, Species, Habitat, and BAPS have been developed. These action plans provide guidance for the conservation and management of biodiversity within the natural environment. This Convention is transposed into UK law by the Countryside and Rights of Way Act (2000).

The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)

19.2.5 Annex V of the Convention provides a framework for contracting parties to develop their own conservation measures. Article 2 requires parties to ‘take necessary measures to protect and conserve the ecosystems and the biological diversity of the maritime area, and to restore, where practicable, marine areas which have already been adversely affected’.

b) European Directives

i. EC Directive on the Conservation of Wild Birds (209/147/CE) (Birds Directive)

19.2.6 The ‘Birds Directive’ aims to protect all wild birds, their eggs, nests and habitats within the EC. It also provides for the protection, management and control of all species of naturally occurring wild birds that are considered rare or vulnerable within the EC as listed in Annex I of the Directive. Under the Directive the most suitable areas for the conservation of these species (land and sea) are classified as SPAs. In England and Wales the Directive is implemented under the Wildlife and Countryside Act 1981 (as amended) and the Conservation (Natural Habitats, &c) Regulations 1994 (as amended). Of relevance to the proposed development is the Severn Estuary SPA.

19.2.7 The Severn Estuary qualifies as an SPA under Article 4.1 of the Birds Directive because it is classified as a wetland of international importance regularly supporting at least 20,000 waterfowl. In addition, it supports internationally important Annex I populations of over-wintering Bewick’s swan *(Cygnus columbianus bewickii)*, curlew *(Numenius arquata),* dunlin *(Calidris alpina alpina),* pintail *(Anas acuta)*, redshank *(Tringa totanus)* and shelduck *(Tadorna tadorna)*, and on passage ringed plover *(Charadrius hiaticula)*.

19.2.8 The implications of HPC with respect to the designated interests of the SPA are covered in the chapter on Terrestrial Ecology and Ornithology (**Volume 2**, **Chapter 20**) and in the Habitats Regulations Assessment (HRA) Report.

ii. EC Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (Habitats Directive)

19.2.9 Under the Habitats Directive, SACs can be designated to maintain or restore the habitats listed in Annex I and the species listed in Annex II of the Directive to ‘Favourable Conservation Status’. This is defined in the context of habitats, as the establishment of conditions which will ensure that the extent and range of the habitat, and the populations of the species within that habitat, will be maintained or increased over time. In relation to species, the viability, population size and range of the species should be maintained in the long-term. In England and Wales the Directive is implemented under the Conservation (Natural Habitats) Regulations 1994 (as amended). Of relevance to the proposed development is the Severn Estuary Special Area of Conservation (SAC).

19.2.10 In 2009, the Severn Estuary was nominated as a SAC under the Directive. The designation is primarily due to the presence of the Annex I habitats: 'Atlantic salt meadows', 'estuaries' and 'mudflats and sandflats not covered by seawater at low tide'. The Annex I habitats: 'sandbanks which are slightly covered by seawater all the time' and 'reefs' are also present as qualifying features, but are not the primary reasons for the designation. The site is also designated due to the presence of the Annex II species: twaite shad, sea lamprey and river lamprey.

19.2.11 Ref. 19.158 gives the most recent guidance on the implementation of the Habitats Directive and the recent judgements regarding compensatory mechanisms where plans or projects affect the conservation objectives of a designated site. The implementation of the Habitats Regulations relies on determining the impact of the plan or project on the Conservation Objectives of the European Site. The Conservation Objectives for the European Sites and the qualifying features for the Ramsar sites are given in Ref. 19.159.

19.2.12 A report to inform the relevant Habitats Regulations Assessment (HRA) is being submitted in parallel to this ES as part of the DCO application.

iii. The Water Framework Directive (2000/60EC)

19.2.13 The Water Framework Directive (WFD) requires that all inland and coastal waters within defined river basin districts must reach at least 'good status' (or 'good potential', if considering a heavily modified water body) by 2015 and defines how this should be achieved through the establishment of environmental objectives and ecological targets for surface waters. Under the requirements of the Directive, the present water quality status must be assessed and any significant water quality issues identified. The overall aim is to enhance water resource quality, reduce pollution and promote sustainable use of water resources.

19.2.14 The WFD is implemented in the UK under The Water Environment (England and Wales) Regulations 2003. Coastal and estuarine waters have been split up into water bodies by the "competent authority" (Environment Agency for England and Wales) and these bodies are assessed individually. Bodies are grouped according to a type defined by hydromorphological assessment, physico-chemical criteria and are designated as coastal or transitional. The area of the Inner Bristol Channel under consideration is regarded as a coastal water from the English shore across to the Welsh shore and the Parrett is a transitional (estuarine) water.

19.2.15 WFD prioritises ecological assessment as a way of classifying water bodies but also includes physico-chemical assessment and the use of environmental chemical standards for priority substances and specific pollutants, as well as an assessment of defined hydromorphological criteria.

19.2.16 Five biological groups of metrics (quality elements) are used to assess ecological status in transitional waters: phytoplankton, macroalgae, angiosperms, benthic invertebrate fauna and fish, and three quality elements for coastal waters: phytoplankton, macroalgae plus angiosperms and benthic invertebrate fauna. Macroalgae and angiosperms are combined for coastal waters but not for transitional waters. Angiosperms cover both sea grasses and salt marshes.

19.2.17 A WFD assessment is provided in Appendix 18B.

iv. EU Marine Strategy Framework Directive

19.2.18 The objective of the EU's Marine Strategy Framework Directive is for EU marine waters to achieve good environmental status by 2021 and to protect the resource base upon which marine-related economic and social activities depend. This Directive constitutes the environmental component of the EU's future maritime policy which has been designed to achieve the full economic potential of the oceans and seas while conserving the marine environment.

19.2.19 Under the Directive, each Member State within a marine region is required to develop strategies for their marine waters. These strategies must contain a detailed assessment of the state of the environment, a definition of "good environmental status" at a regional level and the environmental targets and the establishment of monitoring programmes. Cost-effective measures must be drawn up which include an impact assessment which details a cost-benefit analysis of the proposed measures.

19.2.20 The overall goal of the Directive is in line with the objectives of the Water Framework Directive which requires surface freshwater and ground water to be ecologically sound by 2015 for which the first review of the River Basin Management Plans should take place in 2020. It has been agreed that where the Marine Strategy Framework Directive (MSFD) overlaps with the WFD in coastal waters those assessments undertaken for WFD do not need to be repeated under MSFD. However there are a number of biological components where the MSFD requires assessment and WFD does not, such as cetaceans, fish and birds as well specifically mentioning inputs of energy. Specific standards or methods are not yet determined but are likely to be less detailed than those created for the WFD.

c) National Legislation

i. The Conservation of Habitats and Species Regulations 2010

19.2.21 These Regulations succeed the original Conservation (Natural Habitats, &c) Regulations 1994 and consolidate all the various amendments made to the 1994 Regulations in respect of England and Wales (herein referred to as the Habitats Regulations).

19.2.22 The Regulations implement the Habitats and Birds Directives (described earlier). The Regulations make provision for the protection and management of sites, including the control of potentially damaging operations that may affect designated sites.

ii. The Wildlife and Countryside Act 1981

19.2.23 The Wildlife and Countryside Act (WCA) (as amended by the Countryside and Rights of Way Act 2000 (CRoW)) consolidates and amends existing legislation to implement the Bern Convention and the Birds Directive. The WCA strengthens provisions under the National Parks and Access to the Countryside Act 1949 to establish NNRs in England and Wales. The legislation provides for the designation, protection and management of NNRs which can be established on land and land covered by water, so it can therefore extend into the intertidal zone, but not below low water (e.g. the Bridgwater Bay NNR). These areas can be designated for their flora, fauna or geological interests. The WCA provides for the designation of SSSIs, and Marine Nature Reserves.

19.2.24 Bridgwater Bay is a designated SSSI and comprises a wide range of habitats ranging from extensive intertidal mudflats and saltmarsh to shingle beach and grazing marsh intersected by freshwater and brackish ditches. It is important both nationally and internationally for the overwintering and passage of large numbers of migrant waders and waterfowl. Bridgwater Bay was designated a wetland of international importance under the Ramsar Convention and a NNR under Section 23 of the National Parks and Access to the Countryside Act 1949.

iii. Countryside and Rights of Way Act 2000

19.2.25 The Countryside Rights of Way (CRoW) Act provides for public access on foot to certain types of land, amends the law for public rights of way, increases protection for SSSIs and strengthens wildlife enforcement legislation and provides for better management of Areas of Outstanding Natural Beauty (AONB).

iv. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2010 SI 3242

19.2.26 The Regulations provide the mechanism to implement river basin districts within England and Wales in accordance with the WFD. The Regulations require a new strategic planning process to be established for the purpose of managing, protecting and improving the quality of water resources.

v. Water Resources Act 1991

19.2.27 The Water Resources Act (WRA) came into effect in 1991 and replaced corresponding sections of the Water Act 1989. The WRA sets out the responsibilities of the Environment Agency in relation to water pollution, resource management, flood defence, fisheries, and in some areas, navigation. The WRA regulates discharges to controlled waters, namely rivers, estuaries, coastal waters, lakes and groundwaters. This is distinct from the drainage of water or trade effluent from trade premises into a sewer. Discharge to controlled waters is only permitted with the consent of the Environment Agency. An aim of the Act is to ensure that the polluter pays the cost of the consequences of their discharges.

vi. Planning Policy Statement 9 (PPS9) Biodiversity and Geological Conservation

19.2.28 Planning Policy Statement 9 (PPS9) sets out the Government's national planning policies on the protection of biodiversity and geological conservation through the planning system. Government objectives in relation to biodiversity and geological conservation aim to conserve, enhance and restore biodiversity, and promote sustainability. The aims and objectives of PPS9 are delivered via Regional Spatial Strategies and Local Development Frameworks implemented by the regional and local planning bodies.

19.2.29 PPS9 establishes a series of key principles that regional planning bodies and local planning authorities should adhere to in order to ensure that the potential impacts of planning decisions on biodiversity and geological conservation are fully considered. This is accompanied by Office of the Deputy Prime Minister (ODPM) Circular 06/2005 which provides administrative guidance on the application of the law relating to planning and nature conservation. There is the need to determine environmental effects under other EC Directives, such as the Habitats Directive (92/43/EEC), the Wild Birds Directive (79/409/EEC), the Integrated Pollution Prevention and Control Directive (96/61/EC) or the Control of Major Accident Hazards Directive (96/82/EC). There are links between all of these even though their requirements and those of the EIA Directive are independent of each other. Advice on the links between these, as enabled by the Habitats Regulations, is in PPG 9 on Nature Conservation (or, in Wales, Planning Guidance (Wales) Planning Policy First Revision), and on the links between the Town and Country Planning system and the IPPC authorisation system in PPG 23 on Planning and Pollution Control (or, in Wales, Planning Guidance (Wales) Planning Policy First Revision and Planning Guidance (Wales) Technical Advice Note (Wales) 5 'Nature Conservation and Planning') (Ref. 19.160).

19.2.30 This guidance advises that planning policies and decisions should aim to maintain and enhance, restore or add to biodiversity and geological conservation interests. A strategic approach to the conservation, enhancement and restoration of biodiversity and geology should be taken, recognising the contribution that sites, areas and features (both individually and in combination) make to conserving these resources. Development should contribute to rural renewal and urban renaissance by enhancing biodiversity in green spaces and among developments so that they are used by wildlife and valued by people.

19.2.31 Networks of natural habitats are considered within PPS9 to represent a valuable resource. To reflect their importance, emphasis is placed upon Local Planning Authorities to maintain networks by: “avoiding or repairing the fragmentation and isolation of natural habitats through policies in plans”.

vii. The Marine and Coastal Access Act 2009

19.2.32 The Marine and Coastal Access Act 2009 aims to enable better protection of marine ecosystems and prevent a decline in marine biodiversity. The Act sets out provisions for more coherent planning in the marine environment in terms of issuing consents and permits for activities in the marine and coastal environment. The Act also contains provisions to allow for the designation of Marine Conservation Zones (MCZs) and the creation of a network or Marine Protected Areas (MPAs).

viii. UK Biodiversity Action Plan

19.2.33 The UK BAP is the UK response to the Convention on Biological Diversity 1992. The Plan describes the UK’s biological resources and commits a detailed plan for the protection of these resources. Within the plan, a list of priority species and habitats is developed, for which specific action should be taken to conserve these species and habitats. The implementation of the BAP is the responsibility of various statutory and non-statutory organisations. This is a requirement of the CRoW (2000).

ix. Salmon and Freshwater Fisheries Act 1975

19.2.34 The Salmon and Freshwater Fisheries Act 1975 (SAFFA), as modified by the Marine and Coastal Access Act 2009, applies to salmon, trout (including sea trout) and freshwater fish. The 1975 Act contains rules governing the: Prohibition of Certain Modes of Taking or Destroying Fish, Obstructions to Passage of Fish, Times of Fishing and Selling and Exporting Fish, Fishing Licences, Authorisations, Administration and Enforcement.

x. Eel Management Plans

19.2.35 In accordance with Article 4 of Council Regulation (EC) No 1100/2007 of 18 September 2007, which established measures for the recovery of the stock of European eel, the UK submitted 15 Eel Management Plans for approval by the Commission in December 2008. These plans are set at the River Basin District level, as defined under the Water Framework Directive 2000/60/EC, covering England and Wales, Scotland and Northern Ireland.

19.2.36 Eel Management Plans have been implemented for the Severn Catchment which aim to provide an escapement of silver eel biomass that is at least equal to 40% of the potential escapement to be expected in the absence of anthropogenic influence. In addition, the European Eel Regulation requires that a system is in place to ensure that by 2013, 60% of eel less than 12 cm long which are caught commercially each year are used for restocking in suitable habitat.

19.2.37 To meet the European Eel Regulation cited above, the Eels (England and Wales) Regulations 2009 (Statutory Instrument No. 3344) came into force on 15 January 2010. These Regulations establish measures for the recovery of the stock of European eel for England and Wales. These domestic regulations will enable the protection and sustainable management of the populations of European eel by addressing the passage of eels. Part 4 of the Regulations provides the Environment Agency with powers to serve notice on an owner, occupier or responsible person to: 'make provisions for the passage of eels through dams and other obstructions, and require the placement of screens that will protect eels over some intakes and outlets (i.e. in a diversion structure)'.

d) Regional Planning Policy

i. Somerset and Exmoor Joint Structure Plan 1996-2016

19.2.38 The Joint Structure Plan (JSP) provides the strategic base for all land use planning in the combined area covered by Somerset and the Exmoor National Park for the period up to 2016. The Plan has been prepared as a JSP between Somerset County Council and the Exmoor National Park Authority. The JSP policies relevant to marine ecology in the vicinity of the proposed development include Policy 1: Nature Conservation and Policy 15: Coastal Development. These are described as:

- Policy 1 - Nature Conservation, states that the biodiversity of Somerset (and the Exmoor National Park) will be protected, conserved, restored, enhanced, and managed in accordance with the UK and relevant regional and local BAPs. Spatial target habitats are provided for coastal sand dune, coastal vegetated shingle, and *Sabellaria alveolata* reef. Maintenance target areas are set for coastal sand dune and coastal vegetated sand dune, however, the full extent of *S. alveolata* reef is not known. A target has been set to mitigate the natural loss of coastal sand dune, although establishment and restoration targets are ongoing for coastal vegetated shingle and *S. alveolata* reef.
- Policy 15 - Coastal Development, predominantly considers development on the coast and emphasises the importance of protecting and enhancing natural marine resources including those afforded international protection.

19.2.39 Of the habitats listed above, all have a maintenance target area and all, but *Sabellaria* reefs and seagrass beds, have targets for the years 2010 and 2020. The aforementioned habitats are described as having non-quantifiable future target areas. In addition, quantifiable maintenance and target areas are not provided for littoral sand and gravel habitats. It is stated, however, that for these habitats, the retention of the existing extent and realisation of opportunities for their expansion, is very important.

e) Local Planning Policy

i. West Somerset Council Local Development Framework

19.2.40 West Somerset Council is currently undertaking public consultation on the Local Development Framework Core Strategy.

ii. West Somerset Council Local Plan (2006)

19.2.41 The West Somerset Local Plan covers the administrative area of West Somerset, excluding Exmoor National Park which has a separate Local Plan.

iii. Local Biodiversity Action Plan LBAP (Sedgemoor and West Somerset)

19.2.42 The Local Biodiversity Action Plan for the Sedgemoor District is currently being prepared. Under the West Somerset BAP, coastal vegetated shingle and *Sabellaria alveolata* reefs are identified as priority habitats.

19.3 Methodology

a) Introduction

19.3.1 The methodology adopted for assessing the potential environmental impacts on the marine environment from the HPC development is set out in **Volume 1, Chapter 7** and this is outlined, together with areas where the marine environment impact assessment is unique, in the following sections.

19.3.2 There is currently no statutory defined methodology for carrying out Environmental Impact Assessment (EIA) in the UK, although there is Government guidance. Accordingly, the approach adopted herein is based on best practice methodology from a number of key UK guidance documents on EIA including, but not limited to, the Department for Communities and Local Government (2000) (Ref. 19.256), Institute of Environmental Management and Assessment, IEMA (2004) (Ref.19.257), Environment Agency (2002) (Ref.19.258) and Institute of Ecology and Environmental Management, IEEM (2006) (Ref. 19.259).

19.3.3 Numerous studies have been conducted examining the biological assemblages of the Severn Estuary and Bristol Channel (e.g. Refs. 19.1, 19.2 and 19.3). In addition, some studies have specifically focussed on the ecology of the area surrounding Hinkley Point (e.g. Refs. 19.4 to 9.14). An important long-term data set, the 'Severn Estuary Data Set' (SEDS) is also available from the monthly sampling of the intake screens at HPB, instigated in January 1981 and continuing to this day. The collection of this data set was begun by the Central Electricity Generating Board

(CEGB) and provides relative abundance data for fish (>80 species), macroinvertebrates (>20 species) and planktonic organisms (>40 species).

b) Marine Studies Specific to Hinkley Point C

i. Introduction

19.3.4 A series of field investigations has been undertaken to provide additional baseline data and appropriate numerical modelling tools have been developed in order to inform both environmental assessment procedures and support considerations of appropriate engineering design. Experience of construction and operational impacts of other UK power stations indicate that the likely impacts of HPC will be evident at different spatial scales. For example, construction of the cooling water intake and outfall structures will be likely to result in localised impacts, whereas the effects of a thermal plume created by cooling water discharged from the outfall could potentially extend over many kilometres. The overall aim of the field survey effort was to establish a contemporary baseline for the intertidal and subtidal species and habitats found on and around Hinkley Point, with respect to both potential localised impacts and potential wider scale impacts such as the cooling water discharges.

19.3.5 A key component of the marine studies has been the British EDF (previously British Energy) Estuarine and Marine Studies (BEEMS) programme. As this programme was acquired by EDF together with British Energy early in 2009, by which time both parties had established marine surveys in the vicinity of Hinkley Point, the programme of survey efforts utilised in this Environmental Statement (ES) reflects the process of rationalisation and integration that subsequently followed.

19.3.6 Where available, methods used for the surveys were based on best practice recommendations including those outlined in the Marine Monitoring Handbook (Ref. 19.15). Aspects of the UK National Marine Monitoring Programme Green Book (Ref. 19.16) were also considered. These documents provide detailed standard methodologies for intertidal and subtidal sampling.

19.3.7 Additional methodologies have been developed or adapted as appropriate from past examples of best practice by BEEMS utilising, when appropriate, expert advice from an Expert Panel established within that framework. These needs have occurred where standard methodologies have been lacking in definition (e.g. for cooling water entrainment, impingement and thermal plume assessment, including numerical modelling approach), in order to inform WFD metrics, or where there has been advantage in asking such a group to consider the site specific context (i.e. key features). The relevant Scientific Advisory Reports issued by the BEEMS Expert Panel are listed in **Table 19.3**.

Table 19.3: BEEMS Scientific Advisory Reports bearing on Methodology and Approach

BEEMS SAR Number	Title	Date	Source
SAR 001 (Ref. 19.17)	Key features of the marine ecosystem off Hinkley Point in relation to new nuclear build	September 2010	Expert Panel
SAR 005 (Ref. 19.18)	Methodology for the measurement of entrainment	March 2011	Expert Panel
SAR 006 (Ref. 19.19)	Methodology for the measurement of impingement	March 2011	Expert Panel
SAR 007 (Ref. 19.20)	Methodology for the measurement of plumes	May 2011	Expert Panel
SAR 008 (Ref. 19.21)	Thermal standards for cooling water from new build nuclear power stations	March 2011	Expert Panel
SAR 009 (Ref. 19.199)	Chlorination by-products in power station cooling waters.	2011	Expert Panel

19.3.8 As described above, the approach and the initial extent of the survey programme was discussed in detail and agreed with stakeholders, including Natural England (NE), the Environment Agency and the Countryside Council for Wales (CCW). Subsequent developments in that programme, further to EDF Energy's acquisition of British Energy, have been discussed both with these bodies separately and in a common forum within the HPC Marine Authorities Liaison Group (MALG), as appropriate.

19.3.9 Relevant reports arising from the BEEMS effort are listed in **Table 19.4** below.

Table 19.4: Feeder Reports Utilised in Preparing the Hinkley Point Marine Ecology Synthesis

(NB this does not include all BEEMS reports relevant to Hinkley Point: others are referenced separately in **Volume 2**, **Chapters 17 and 18**)

BEEMS Report Number	Title	Date	Source
TR016 (Ref. 19.22)	BEEMS Hinkley Point intertidal review of biological and physical habitat information. R.1428	April 2008	ABP mer Ltd.
TR029 (Ref. 19.23)	Ecological characterisation of the intertidal region of Hinkley Point, Severn Estuary: results from 2008 field survey and assessment of risk. Vers. 2	March 2009	Cefas
TR031 (Ref. 19.24)	Nearshore habitat survey	March 2009	Titan
TR039 (Edition 4) (Ref. 19.25)	Seabed habitat mapping: Interpretation of swath bathymetry, side-scan sonar and ground-truthing results	January 2011	Cefas

BEEMS Report Number	Title	Date	Source
TR060 (Ref. 19.26)	Hinkley Point physical sciences report. Hydrodynamics, climatology, sedimentology and coastal geomorphology – an initial assessment of coastal hazards related to potential new nuclear build	December 2009	Cefas
TR065 (Ref. 19.27)	Predictions of impingement and entrainment by a new nuclear power station at Hinkley Point. Edition 2.	September 2010	Cefas
TR067 (Edition 2) (Ref. 19.28)	Hinkley Point nearshore communities: Results of the day grab surveys 2008 – 2010	October 2010	Cefas
TR068 (Edition 2) (Ref. 19.29)	The effects of the new nuclear build on the marine ecology of Hinkley Point and Bridgwater Bay	May 2011	Cefas
TR068b (Ref. 19.30)	Distribution of Coralline turfs at Hinkley Point with respect to nuclear new build	November 2010	Cefas
TR070 (Ref. 19.31)	An initial assessment of the effects of new nuclear build on water quality at Hinkley Point. Edition 3.	February 2011	Cefas
TR071 (Edition 4) (Ref. 19.32)	Review of commercial fisheries activity in the vicinity of Hinkley Point Power Station	February, 2011	Cefas
TR083 (Edition 3) (Ref. 19.33)	Hinkley Point nearshore communities: Results of the 2m beam trawl and plankton surveys 2008 - 2010	November 2010	Cefas
TR083a (Ref. 19.34)	Hinkley Point nearshore Communities: Plankton surveys 2010	November 2010	Cefas
TR104 (Ref. 19.35)	Hinkley Point *Sabellaria* assessment: Analysis of survey data for 2009	January 2010	MES Ltd.
TR129 (Ref. 19.36)	HP Comprehensive Impingement Monitoring Programme 2009-2010	February 2011	Pisces
TR134 (Ref. 19.37)	*Macoma balthica* temperature sensitivity review	January 2011	Cefas
TR135 (Ref.19.38)	HP thermal plume modelling: stage 3 review – detailed evaluation of the validation of the two Stage 3 models	January 2011	Cefas
TR136 (Ref.19.39)	Benthic biological resource characterisation	May 2011	MES Ltd.
TR136A (Ref. 19.40)	Comparison of macrobenthic fauna and sediment characteristics from Hamon and Day grab samples	May 2011	Cefas
TR138 (Ref. 19.41)	BEEMS nearshore habitat survey: Hinkley Point – Bridgwater Bay final report	January 2011	TES Ltd.
TR141 (Ref. 19.42)	Hinkley Point *Sabellaria* assessment: Analysis of survey data 2010	August 2010	MES Ltd.

BEEMS Report Number	Title	Date	Source
TR148 Ed 2 (Ref. 19.43)	A synthesis of impingement and entrainment predictions for NNB at Hinkley Point	March 2011	Cefas
TR153 (Ref.19.44)	Tolerance of *Sabellaria spinulosa* to aqueous chlorine; Final Report	March 2011	SAMS
TR154 (Ref. 19.45)	Hinkley spring intertidal survey and analysis report	November 2010	IECS
TR155 (Ref. 19.46)	Hinkley summer intertidal survey and analysis report	November 2010	IECS
TR156 (Ref. 19.47)	Hinkley autumn intertidal survey and analysis report	March 2011	IECS
TR157 (Ref. 19.48)	Hinkley winter intertidal survey and analysis report	March 2011	IECS
TR158 (Ref. 19.49)	Methods for monitoring the thermal environment of Bridgwater Bay intertidal habitats	April 2011	Cefas
TR160 (Ref. 19.50)	Variability in population structure and condition of *Macoma balthica* along its geographical range	May 2011	Cefas
TR161 (Ref. 19.51)	Initial investigations of the links between intertidal macrofauna and their avian predators in Bridgwater Bay with an Individual-Based Model	May 2011	Cefas
TR162 (Ref. 19.52)	Hinkley Point chlorination responses of key intertidal species – literature review	November 2010	Cefas
TR163 (Ref. 19.53)	Acute and behavioural effects of chlorinated seawater on intertidal mudflat species	April 2011	Cefas
TR164 (Ref. 19.54)	Molecular analyses of faecal material for diet analysis of protected intertidal birds	May 2011	Cefas
TR167 (Ref. 19.55)	Biotope mapping survey of Hinkley Point – Watchet intertidal area (Region 1)	March 2011	IECS
TR169 (Ref. 19.56)	Pile driving and marine life – potential implications for Nuclear New Build at Hinkley Point	January 2011	Cefas
TR170a (Ref. 19.57)	Cetacean Monitoring: 1st report	June 2010	SMRU Ltd.
TR177 (Ref. 19.59)	Hinkley Point thermal plume modelling. GETM Stage 3a results with the final cooling water configuration	February 2011	Cefas
TR178 (Ref. 19.60)	Hinkley Point Modelling: Chemical Plume Modelling (TRO, Hydrazine, DO, Ammonia)	May 2011	Cefas
TR180 (Ref. 19.61)	Hinkley Point intertidal fish and mobile epifauna survey: December 2010	March 2011	APEM
TR183 (Ref. 19.62)	Inter-annual variability in the intertidal mudflat communities of Bridgwater Bay	March 2011	Cefas

BEEMS Report Number	Title	Date	Source
TR184 (Ref. 19.14)	Hinkley Point marine ecology synthesis report	May 2011	Cefas
TR186 (Ref. 19.63)	Predicted effects of new nuclear build on water quality at Hinkley Point	February 2011	Cefas
TR182 (Ref. 19.65)	Delft3D Hinkley Point thermal plume modelling.	February 2011	Cefas
TR187 (Ref. 19.67)	HP thermal plume modelling: selection of meteorological and geomorphological scenarios.	February 2011	Cefas
TR159 (Ref. 19.177)	Intertidal fish survey	August 2010	Apem
TR027 (Ref. 19.222)	Entrainment monitoring feasibility study	January 2009	Jacobs
TR081 (Ref. 19.225)	Laboratory and power plant based entrainment studies: a literature review	October 2008	Jacobs
TR117 Ed.2 (Ref. 19.231)	Assessment of effects of cooling water intake velocity on fish entrapment risk at Hinkley Point	2010	Cefas
TR197 (Ref. 19.236)	Modelling of the optimal position of a FRR system for Hinkley Point C	June 2011	Cefas
TR194 (Ref. 19.239)	Modelling fish deterrents at Hinkley Point C	June 2011	FGS Ltd.
SPP 061 (Ref. 19.248)	Cod in the Celtic and Irish Seas	September 2011	Cefas
SPP 062 (Ref. 19.249)	*Macoma balthica* population structure at Hinkley Point and elsewhere in the Severn Estuary	September 2011	Cefas
SPP 063 (Ref. 19.250)	Entrainment impact on organisms at Hinkley Point C – supplementary note.	September 2011	Cefas
SPP 065 (Ref. 260)	Reassessment of juvenile cod impingement predictions at HPC	September 2011	Cefas

ii. Description of Surveys

19.3.10 Following the initial review of the tidal regime of the area and likely extent of any cooling water plume related issue, a series of high resolution bathymetric surveys using sidescan and swathe sonar of a wide area of the subtidal off Hinkley Point were completed (Ref. 19.25). In combination with high resolution LIDAR (Light Detection and Ranging) survey data obtained from the Environment Agency, the results were analysed to produce detailed maps of bed morphology (**Figure 19.2**) and surface sediment habitat type (**Figure 19.4**), leading in turn to habitat and biotope mapping (**Figure 19.18**).

19.3.11 An initial set of offshore biological surveys was instigated in February 2008 and covered a broad area of the Severn Estuary up to 15km from the proposed position of HPC (the estimated extent of any thermal influence of cooling water discharges) (**Figure 19.5**). The programme then extended to include further off-shore surveys in June, August and November of 2008 and May 2009 for:

- subtidal benthic infauna, sampled with a $0.1m^2$ Day grab;
- subtidal benthic epifauna, sampled with a 2m beam trawl;
- benthic fish, sampled with a beam trawl;
- fish egg and larval abundance, as sampled by Gulf VII high speed plankton net; and
- zooplankton and phytoplankton using standard plankton nets.

19.3.12 Intertidal habitats were surveyed in July 2008. In order to ensure comprehensive spatial coverage of the various biotopes involved, this intertidal sampling was directed by the use of existing biotope maps, where available, arising from earlier studies carried out for Natural England. The area surveyed covered both soft and hard sediments ranging from the intertidal mud and sandflats up to approximately 8km north of the River Parrett Estuary, to the shoreline approximately 15km west of Hinkley Point (**Figure 19.3**). In total 55 sample sites were selected, which consisted of 40 soft sediment locations, 12 rocky shore sites and three sites located on saltmarsh. Sample sites were chosen to cover as wide a range of biotopes as possible within the intertidal zone in the main study area.

19.3.13 A more detailed description of the survey programme is available in Ref. 19.23, 19.27, 19.28 and 19.33.

19.3.14 Findings from the benthic and intertidal studies were subsequently utilised to validate a series of biotope maps that were initially developed on the basis of habitat mapping derived from remote sensing.

iii. Surveys for Intertidal Fish and Mobile Epifauna

19.3.15 Following a review of the existing biological datasets it was recognised that there was a lack of data relating to the utilisation of the intertidal zone by fish and mobile invertebrates. The location of HPC borders a large expanse of intertidal sediments: initial work had identified that this area could fall within the footprint of the thermal plume from the cooling water discharge. A study was initiated in August 2009 with an aim of increasing the knowledge base regarding the numbers and types of species utilising these habitats on both a temporal and spatial basis. To date, six surveys have been conducted over August, October and December 2009 and February, April and June 2010.

19.3.16 To gain a comprehensive understanding of the species utilising these habitats, the survey was designed to incorporate a range of techniques. Although primarily designed to target fish, mobile epifauna caught as bycatch were also recorded. The sampling strategy for fish was designed to follow the best practice WFD ‘multi-method’ approach, utilising a combination of static fyke nets and marginally deployed seine nets. Three sites were selected which were considered to provide a range of habitats and flows typical of the wider area of Bridgwater Bay, which are shown in **Figure 19.5**.

iv. Fish on Screen Surveys

19.3.17 As a check on the long-term fish on screens monitoring at HPB, an additional programme of such monitoring was established utilising a more comprehensive methodology designed to obtain a quantitative, rather than semi-quantitative assessment of the station catch over the course of a year. The methodology used was directly comparable (e.g. Ref. 19.207) to that used for scaling mitigation benefits associated with cooling water intake design improvements at previous nuclear power station developments in the UK.

c) Ecological Impact Assessment Methodology

19.3.18 Specific elements relating to marine ecology have been incorporated into the methodology where appropriate, as set out in the following tables.

i. Value and Sensitivity of the Receptor

19.3.19 The value of a receptor is determined based on geographical context (e.g. international, national, regional, see below) and conservation designations. Where appropriate, the criteria assigned for determining the sensitivity of receptors has been based on information derived from the Marine Life Network (MarLIN). The criteria utilised are summarised in **Table 19.5**.

Table 19.5: Criteria used to Determine Sensitivity and Value for Marine Ecology

Definition	Value and Sensitivity Guidelines
High	**Value** Feature/receptor possesses key characteristics which contribute considerably to the distinctiveness, rarity and character of the site/receptor e.g. Designated features of International/National designation/importance e.g. SAC, SSSI, Ramsar, SPA, BAP. Feature/receptor possess important biodiversity, social/community value and/or economic value. Feature/receptor is rarely sighted. **Sensitivity** Receptor populations are identified as having very low capacity to adapt to, or recover from, proposed form of change i.e. population is highly sensitive to change.
Medium	**Value** Feature/receptor possesses key characteristics which contribute considerably to the distinctiveness, rarity and character of the site/receptor e.g. designated features of Regional/County designation/importance e.g. BAP, Nature Reserves. Feature/receptor possess moderate biodiversity, social/community value and/or economic value. Feature/receptor is occasionally sighted. **Sensitivity** Receptor is identified as having low capacity to accommodate proposed form of change i.e. is moderately sensitive.

Definition	Value and Sensitivity Guidelines
Low	**Value** Feature/receptor only possesses characteristics which are of District or Local importance. Feature/receptor not designated or only designated at the district or local level e.g. LNR. Feature/receptor possesses some biodiversity, social/community value and/or economic value. Feature/receptor is relatively common. **Sensitivity** Feature/receptor is identified as having tolerance to changes within the range of natural variation i.e. is only slightly sensitive.
Very Low	**Value** Feature/receptor characteristics do not make a contribution to the character or distinctiveness locally. Feature/receptor not designated. Feature/receptor possesses low biodiversity, social/community value and/or economic value. Feature/receptor is abundant. **Sensitivity** Feature/receptor identified as being generally tolerant of the proposed change i.e. of low sensitivity.

ii. Magnitude of Impact

19.3.20 The criteria used to assign magnitude to an effect, with specific regard to marine ecological interests, are set out in **Table 19.6**.

Table 19.6: Criteria for Determining Magnitude for Effects on Marine Ecology

Magnitude of impact	Criteria
High	The quality and availability of habitats and species are degraded to the extent that locally rare populations and habitats are destroyed and protected species and habitats experience widespread change, such that the integrity of the ecosystem and the conservation status of a designation may be compromised. Activities predicted to occur and affect receptors continuously over the long-term, and during sensitive life stages. Recovery, if it occurs, would be expected to be long-term i.e. ten years following the cessation of activity. Impacts not limited to areas within and adjacent to the development.
Medium	The quality and availability of habitats and species are degraded to the extent that the population or habitat experiences reduction in number or range. Activities predicted to occur and affect receptors regularly and intermittently, over the medium to short-term and during sensitive life stages. Recovery expected to be medium term timescales i.e. five years following cessation of activity. Impacts largely limited to the areas within and adjacent to the development.
Low	The quality and availability of habitats and species experience some limited degradation. Disturbance to population size and occupied area within the range of natural variability. Activities predicted to occur intermittently and irregularly over the medium to short-term. Recovery expected to be short-term i.e. one year following cessation of activity. Impacts limited to the area within the development.

Magnitude of impact	Criteria
Very Low	Although there may be some impacts on individuals it is considered that the quality and availability of habitats and species would experience little or no degradation. Any disturbance would be in the range of natural variability. Activities predicted to occur occasionally and for a short period. Recovery expected to be relatively rapid i.e. less than approximately six months following cessation of activity. Impacts limited to the area within the development.

iii. Significance

19.3.21 The significance of the impact is judged on the relationship between the magnitude of effect and the assessed value and sensitivity of the receptor. The methodology used to assess the predicted significance of impacts, without mitigation, is outlined in **Volume 1, Chapter 7**.

19.3.22 For the purpose of this impact assessment, statutory designations and any potential breaches of environmental legislation take precedence in determining significance, because the protection afforded to a particular receptor or resource has already been established as a matter of law. Thus, using the defined criteria and IAM, features to which designations apply have automatically been determined to be of high value (or of a higher value than non-designated features), and as a result any impact tends to be of a greater significance than an impact on features to which no designation applies. Hence, for designated features, the use of the value criteria leads to an initial presumption that impacts will be of a high significance. Information on sensitivity can then be used to modify or maintain this initial assessment as appropriate.

d) Definition of Area of Effect

i. Introduction

19.3.23 The layout of the existing HPA and HPB cooling water (CW) intake and outfalls, together with the analogous HPC intakes and outfalls, is shown in **Figure 19.6**.

19.3.24 Thermal plume modelling was undertaken using both the General Estuarine Transport Model (GETM) and Delft 3D models (see Refs. 19.59, 19.65, 19.38, 19.67) to determine the area of effect of HPC on the marine environment. These models have been employed as a complementary 'ensemble' following Environment Agency guidance (see Ref. 19.68 and **Appendix 18A** to **Volume 2 Chapter 18**), and utilise the same physical data inputs but different algorithms for the solution of a range of variables in order to gain greater confidence over the degree of predictive uncertainty involved.

19.3.25 Both models were subject to the same degree of independent peer review, and identical requirements for calibration and validation against independent data sets. This ensemble was used to support both engineering design considerations and environmental considerations.

19.3.26 Model outputs used to inform this particular appraisal have been obtained primarily from the GETM model which, from experience in its use together with other models in similar circumstances, is known to predict slightly higher seawater temperatures in the mid to far field area of the thermal plume. The GETM outputs thus provide an indication of the upper bound of the temperature range likely to be experienced, whilst the Delft 3D outputs can be considered to reflect a lower boundary. Differences between such models, even when utilising the same input values and subject to audit against a standard set of criteria, are to be expected.

19.3.27 The outputs described here are provided in order to illustrate the extent of the thermal plume across the whole tidal cycle for neap and spring tides and thereby the area of effect of HPC.

19.3.28 The sea temperature of Bridgwater Bay and the River Parrett Estuary has been known to range naturally from 2 - 23ºC (Ref. 19.3). Key modelling outputs required to inform the assessment, indicating modelled increases above ambient temperature due to the thermal plumes of both HPC and HPB, are provided in **Volume 2**, **Chapter 18** of this ES, 'Marine Water and Sediment Quality' and are briefly summarised below.

19.3.29 As the key environmental sensitivity associated with the behaviour of the thermal plume is the impact on habitats, primarily the marine ecology in intertidal areas of Bridgwater Bay, the extent of plume intrusion into these areas has been taken to be the key indicator of environmental impact when evaluating possible intake and outfall locations. The modelling outputs have been employed in support of an assessment of the functional ecological implications of plume behaviour, described later within this chapter and within the HRA.

ii. Baseline and other Scenarios Tested

19.3.30 Three scenarios for HPC intake and outfall configurations were tested to simulate the range of potential locations and their effects on the environment. The range of intake and outfall positions tested is illustrated by **Figure 19.7**.

Table 19.7: Total Estimated Areas (in km^2) of Mean Annual Temperature Uplift due to Thermal Plumes from Different Power Station Intake/Outfall Configurations and Operational Regimes (from Ref. 19.59)

Configuration under Test		Thermal Uplift					
Hinkley Point C Load	Hinkley Point B Load	>1 °C Area (km^2)	>2 °C Area (km^2)	>3 °C Area (km^2)	>4 °C Area (km^2)	>5 °C Area (km^2)	>6 °C Area (km^2)
Tests for initial selection of Hinkley Point C discharge location – with simulated cooling water volumes of 120m^3/sec^{-1} at an average temp. of 12.2°C							
Cross shore discharge; 100% - Configuration 2	0%	22.6	6.22	1.502	0.377	0.166	0.053
Intermediate discharge; 100% - Configuration 3	0%	27.2	4.10	0	0	0	0
Offshore discharge; 100% - Configuration 1	0%	25.2	0.43	0	0	0	0

Configuration under Test		Thermal Uplift					
Hinkley Point C Load	Hinkley Point B Load	>1 °C Area (km^2)	>2 °C Area (km^2)	>3 °C Area (km^2)	>4 °C Area (km^2)	>5 °C Area (km^2)	>6 °C Area (km^2)
Tests using refined engineering information on selected offshore discharge location (configuration 5a) – with simulated cooling water volumes of 125m³/sec at an average temp. of 11.6°C and, for Hinkley Point B station (100% load) 53m³./sec⁻¹ at an average temp. of 10°C							
0%	100%	6.9	1.35	0.036	0	0	0
0%	70%	4.0	0.05	0	0	0	0
100%	70%	40.3	11.42	0.471	0.007	0	0
100%	0%	29.6	2.86	0.003	0	0	0

19.3.31 Allowing the cooling water of HPC to discharge directly onto the intertidal area west of Hinkley Point (termed 'Configuration 2') was found to result in a transport of heated water to the east, close to shore, resulting in an area of 1.4km^2 of intertidal habitat being exposed to an annual increase in water temperature of >2°C. Moving the outfall a moderate distance offshore ('Configuration 3') reduced this impact to 0.4km^2 and moving it a long distance offshore reduced the area of intertidal habitat subject to >2°C increase to zero ('Configuration 1').

19.3.32 'Configuration 1' thus produced the least thermal effect on the intertidal habitat and so became subject to engineering refinement in order to capture a realistic flow regime, a refined inlet design and modified intake/outfall locations informed by subsea geology, resulting in test 'Configuration 5a'. On testing, this configuration maintained the area of habitat subject to >2°C annual temperature uplift at essentially zero.

19.3.33 Further modelling was then undertaken to predict the combined effect of the proposed HPC station using 'Configuration 5a', with HPB at its current loading of approximately 70%. This in-combination configuration (termed 'Configuration 6a') showed a large intersection between thermal plume and intertidal habitat (see **Table 19.8**). This simulation estimated that an area of 2.55km^2 (2550ha) of Stolford Bay and Stert Flats would be exposed to temperature increases of >2°C. This comprises 2.31km^2 of low Total Prey Availability (TPA) and 0.24km^2 of medium TPA habitat (see Ref. 19.14), based on a formal classification of the invertebrate populations involved, and their availability as prey to higher trophic levels (this measure describes the availability of the overall macro-infauna food resource, using the summed biomass of all species present at a particular location; in this respect, it takes no account of individual preferences for particular prey species, summarising the total potential food available to birds across the site). Such an in-combination impact would only occur over a period in which both HPB and HPC were operational.

19.3.34 HPB is currently scheduled to cease operation in 2016. If it does so then there will be no overlap between the operation of HPB and HPC and, therefore, no in-combination impact involving the thermal plumes would arise. However, EDF Energy has stated that it will seek life extensions across its Advanced Gas-cooled Reactor (AGR) fleet (which includes HPB) of an average of 5 years, and longer if safe and economic to do so. There is thus a possibility that the operation of HPB may be extended beyond 2016. As a result there is a need to assess the impact of the continued generation of the two power stations both alone (HPB for baseline purposes) and in combination with respect to the influence of the thermal plume on marine ecology. For further discussion of the baseline assumptions incorporated in this assessment, see **Section 19.5** on **Scope of Assessment** below.

19.3.35 Should HPB operate at 100% load, the estimates provided in **Table 19.7** and **Table 19.8** suggest that the operation of HPC alone, using the distribution of the >2°C uplift, would effectively have no impact over potentially sensitive areas.

Table 19.8: Estimated Areas (in km^2) of Intertidal Habitat Impacted by Mean Annual Temperature Uplift Due to Thermal Plumes from Different Power Station Operational Regimes, Utilising Offshore Hinkley Point C Discharge Location (from Ref. 19.59)

Operational Regime		TPA Class	Thermal Uplift		
Hinkley Point C	Hinkley Point B		>1 °C) Area (km^2)	>2 °C) Area (km^2)	>3 °C) Area (km^2)
0%	100%	Low	1.67	0.61	0
		Medium	0.45	0	0
		High	0.57	0	0
		Very high	0.29	0	0
0%	70%	Low	1.30	0	0
		Medium	0.18	0	0
		High	0.15	0	0
		Very high	0.09	0	0
100%	70%	Low	4.59	2.31	0.10
		Medium	2.78	0.24	0
		High	0.68	0	0
		Very high	0.29	0	0
100%	0%	Low	3.74	0.03	0
		Medium	1.20	0	0
		High	0.10	0	0
		Very high	0	0	0

iii. General Understanding of the Ecological Effects of a Thermal Plume

19.3.36 A review of available literature and research findings has been undertaken to ascertain the potential effects that the change in the thermal regime associated with the HPC cooling water discharge may have on the marine environment. The material reviewed relates to a range of situations in which thermal impacts have been investigated in a range of geographical locations. Sources include the body of information generated during the BEEMS programme of studies.

19.3.37 A number of studies have been undertaken over the past 30-40 years to investigate the impacts of thermal effluent discharges on aquatic ecosystems around the world. These studies have indicated that the long-term discharge of thermal effluents into the coastal environment can result in significant community changes (Ref. 19.69) and have the potential to affect all components of estuarine ecosystems. These studies also indicate that these effects are commonly limited to a restricted area within a few hundred metres of the vicinity of the discharge point, depending on local tidal conditions (Ref. 19.70).

19.3.38 Ref. 19.21 lists some other studies on the response of marine communities to power station discharges outside the UK.

19.3.39 The water column of an estuary is generally well-mixed in terms of temperature and the temperature-stratification of a plume is predicted to vary depending on environmental factors such as temperature of the surrounding water and meteorological conditions. Turbulent conditions (e.g. from storms) will increase heat-loss by mixing with the receiving waters, while high winds will increase heat-loss by radiation to the air. Generally, the heated plume will be less dense and thus more buoyant than the receiving water, and so will rise to the surface and restrict direct impingement of the discharge water on the seabed. However, the plume may be the only layer of water in direct contact with shallow littoral habitats (see **Volume 2**, **Chapters 17** and **18**, and Ref. 19.20).

19.3.40 The potential impacts of a thermal discharge can be classed as direct or indirect impacts. The direct potential temperature impacts of thermal plume discharge fall into four categories (Ref. 19.71):

- the mean temperature in relation to normal temperature (the water is warmer);
- the absolute temperature (as it may approach lethal levels);
- short-term fluctuations in temperature (particularly tidally-driven); and
- barriers to fish migration.

19.3.41 Responses of marine organisms to the conditions allied with a thermal discharge can range from physiological effects, extended growing and reproductive seasons, increased metabolism, and behavioural changes associated with perceived stress (e.g. emigration) or use of defence mechanisms such as shell closure in bivalves, to debilitation (possibly increasing susceptibility to predation) or mortality. Other than the last two, such responses may be positive or negative. Generally, warmer-water species (those distributed further south in the northern hemisphere) are more tolerant of higher temperatures than are colder-water species. Species whose distribution includes the littoral zone are more tolerant than those from the sublittoral, and, within species, different populations are adapted to different thermal tolerances as a result of selection to their ambient habitat (Ref. 19.21).

19.4 Baseline Environment

a) Influence of the Physical Environment

19.4.1 The Severn Estuary has one of the largest tidal ranges in the world, reaching in excess of 13m at Avonmouth, a regime classified as 'hypertidal'. The extreme tidal and turbidity regimes of the Severn Estuary make it unique amongst British estuaries, with the physical environment strongly influencing the distribution and productivity of the biological assemblages present.

19.4.2 A consideration of these physical key features (see Ref. 19.17) is provided in **Volume 2**, **Chapter 17**, Coastal Hydrodynamics and Geomorphology, of this ES. Where particularly relevant to discussion within this chapter, certain key physical features are repeated here. **Table 19.9** below summarises the key ecological features that, in large part, arise from these dynamic conditions.

Table 19.9: Key Features of the Severn Estuary and Bristol Channel Relevant to the Marine Ecology of Hinkley Point (after Ref. 19.17)

Key Features: Physical	Comment
Large funnel shaped estuary facing the Atlantic	Influences fish species (particularly migratory) and other physical features, particularly tidal regime.
Large branching estuary	Sub-estuaries absorb energy at tidal frequencies, but input energy at longer frequencies because of river flow variation. The Parrett, Usk and others are not insignificant regarding freshwater influx into the system.
High salinity variation	Seasonal and tidal variation – River Parrett significantly adds to this in the Hinkley Point area.
Hypertidal	Rare at global scale – includes Bay of Fundy (Canada), the Seine and the Somme (France).
Periodic energy inputs	Spring to neap changes are major in magnitude, resulting in a system with a major component of fortnightly change (as well as other tidal periods). Long periods of low winds reduce the suspended solids concentrations, at least in surface waters. The sedimentary system is therefore periodic, which directly affects the light regime (hence production), the benthic habitats and thus the benthos.
Waves dominant in shallow water	In shallow areas, waves are dominant over the effects of tidal currents. Most important in the Hinkley Point area are the intertidal and shallow 'flats' where it is waves that are mostly responsible in terms of mobilising and/or changing the physical environment and thus affecting the biota.
Surprisingly sediment starved	The vast majority of the seabed in the Bristol Channel and Severn Estuary system is rock or coarse gravel; there is relatively little sand, and most (though not all) of the mud is in suspension or is intermittently mobilised.
Physics makes change in subtidal habitats the norm not the exception	Changes to the sediment transport system have the potential to induce major changes in habitat. Changes in sediment distribution (natural and man made) are likely and these will affect habitats – by definition.
Highly turbid – unique in UK	High concentrations of sediment are present within the water column (in both permanent and temporary suspension and is intermittently deposited) but there is relatively little contribution from the rivers or from the Outer Bristol Channel.
Entrance to Parrett – mobile banks	The mouth of the Parrett has a variety of intertidal and subtidal banks, which consist of layered sediments and are extremely mobile. They thus tend to have low density biota.
Existing Parrett plume impact on intertidal area	Freshwater runoff peaks are significant in that they affect the extent of the existing HPB thermal plume across Bridgwater Bay.
Periodic major changes in bed elevation	Erosion/deposition cycles occur naturally and periodically, especially in outer Bridgwater Bay.

Key Features: Physical	Comment
Coastline and seabed near Parrett susceptible to change	The Stert Flats peninsula is susceptible to breaching in the longer term (century scale), and breaching would significantly affect cooling water flows across the (greatly changed) intertidal habitats.
Residual circulation	Tidal averaging of flows shows strong outward residual flow from Flat Holm to the south side of channel off Kilve. Recirculation cells occur to north and south. This could both trap persistent contaminants or effluent, and provide routes for fish migration. Crudely summarised as: 'fish in north, out south'. This feature persists to the Holm Islands. Given the small magnitude of any residual circulation compared to the regular tidal flows, the significance of this feature is uncertain.
Benthic production dominated by intertidal compared to subtidal	Due to a combination of the distribution of tidally driven bed shear forces and the extreme levels of turbidity present in the water column, there is an apparent discontinuity in ecological production with little subtidally and that, over the soft intertidal areas, driven largely by microphytobenthos. The balance of primary production is thus skewed towards the intertidal zone.
Contains sub-systems which are relatively simple	The Bridgwater Bay ecosystem is relatively simple with few species dominant. Mysids, crabs and brown shrimp (*Crangon*) are important links in the food chain.
Migratory fish corridor	Important for a number of species of conservation interest (shad, salmonids, eel, lampreys).
Impoverished subtidal benthos	Extremely poor compared to other estuaries, because of periodic highly mobile seabed.
Highly productive intertidal soft shore benthos	Stable highly productive mud flats. The mudflats are of two general types: (1) eroding Holocene muds and clays, which are relatively resistant to erosion and able to form a habitat for infauna, and (2) periodically layered mobile sands and muds.

19.4.3 Recent hydrographic studies show that at offshore sites (1km to approximately 5km from the coast) tidal currents may reach a maximum velocity of 1.7m.s^{-1} on spring tides and 1.4m.s^{-1} on neap tides. Velocities were slightly lower at the nearshore site approximately 500m from the coast (peak of 1.5m.s^{-1} on springs and 1.0m.s^{-1} on neaps). Ebb currents were found to be stronger than on the flood tide at all locations.

19.4.4 An estimated 10 million tons of sediment is carried in suspension within the estuary on spring tides (Refs. 19.74 and 19.75). The consequent extreme turbidity levels within the estuary reduce the depth of the photic zone and limits growth of phytoplankton. Turbidity data for sites located off Hinkley Point (>1.5km from the coast) indicate that suspended solids can reach concentrations of 1g.l^{-1} on both the ebb and flood of spring tides. At some locations, advective processes may be more important than local re-suspension processes in terms of determining suspended solid loads.

19.4.5 Literature relating to the invertebrate fauna of the Severn Estuary and the Bristol Channel describe the benthic macrofauna of the region as impoverished when compared with other estuaries, both in terms of the number of species and their abundance (Refs. 19.92, 19.93, 19.94 and 19.242). This finding is supported by the recent BEEMS studies (e.g. Refs. 19.28 and 19.40) around Hinkley Point. The large tidal movements and associated turbidity regime result in an extremely stressful physical environment in which benthic assemblages are primarily influenced by powerful tidal shear forces and the regular deposition, re-suspension and mobilisation of bottom sediments. These stressors restrict the number of species able to tolerate conditions within the estuary. In addition, no macroalgae occur subtidally as a result of a predominance of muddy sediments and the high turbidity of the water. Extreme storm events can also raise turbidity levels within the estuary and result in further temporary changes to estuarine assemblages in the vicinity of Hinkley Point.

19.4.6 The major drivers influencing the macrofaunal populations and species diversity and abundance are thus the high tidal shear forces and chronic sediment surface instability combined with the high turbidity, limiting subtidal primary production. In contrast, the shallower intertidal areas where tidal shear becomes progressively less significant are relatively stable, providing opportunity for the algal growth that is effectively restricted within the water column itself.

b) Phytoplankton and Other Sources of Primary Production

19.4.7 Due to the high suspended sediment concentrations, the photic depth in the estuary is confined to the immediate surface waters, which greatly limits the primary production of phytoplankton (Refs. 19.76-79). Although some phytoplankton are present in the highly turbid sections of the Bristol Channel, primary production rates are far greater in the less turbid areas. Intertidal sediments in the Severn Estuary are known to support microphytobenthic populations, which are frequently dominated by diatoms (Ref. 19.80). The re-suspension of these algae (and the substrates they inhabit) has been demonstrated in the Ems Estuary in The Netherlands, a large, physically dynamic estuary similar to the Severn (e.g. see Ref. 19.81). This strongly suggests that it is largely re-suspended microphytobenthos that contributes to the phytoplankton recorded in local open waters.

19.4.8 There is limited published information available regarding phytoplankton populations in the Bristol Channel and Severn Estuary. Refs 19.82 and 19.83 provide some data on phytoplankton species recorded in the Inner Bristol Channel. Of the diatom species indicated in these records some species are primarily benthic (e.g. *Actinoptychus* spp., *Bacillaria paxillifer, Gyrosigma* spp., *Melosira arctica* and all the *Nitzschia* species), while planktonic species include *Asterionella* spp., *Chaetoceros* spp, *Ditylum brightwellii*, *Odontella* spp. and *Helicotheca tamesis*. This suggests that at least some of phytoplankton component has a microphytobenthic origin.

19.4.9 In total 21 species were recorded off Hinkley Point from the phytoplankton surveys carried out between November 2008 and October 2009. The most frequently recorded species between November 2008 and July 2009 was the diatom *Odontella regia* which was present at all, or nearly all, of the sites on each occasion. This species also had the greatest density with the highest values recorded in July 2009 (reaching up to 1006 individuals per m^{-3}). However, this species was not recorded in the August and October 2009 samples, with *Paralina sulcata* being present at all sites in August and *Odontella sinensis* present at nearly all sites during October. The densities of phytoplankton varied among sampling periods with the highest phytoplankton densities recorded in July 2009, at a mean density of 278 individuals per m^{-3} (which was mainly due to high numbers of *O. regia*). However, when compared with other British coastal waters, phytoplankton densities were relatively low (Ref. 19.84).

19.4.10 The most frequently recorded species, *Odontella regia*, is regarded as a planktonic form. This species was found to occur in a 'low light' group of algae at Helgoland, in the North Sea around Germany (Ref. 19.85) suggesting it may be capable of growth within the extreme conditions of the Severn Estuary. In contrast, *G. delicatula* and *S. unipunctata* are more typical of coastal waters, suggesting they may have been transported into the estuary.

19.4.11 Ref. 19.253 summarises the carbon production budgets for the Bristol Channel. This analysis found annual primary production to be 165g $C.m^{-2}.y^{-1}$ in the Outer Bristol Channel but only 6.8g $C.m^{-2}.y^{-1}$ in the Inner Bristol Channel (excluding a contribution from the *Phaeocystis pouchetti* bloom which occurred in most years in the Central Channel in June). Peak production in the Outer Channel occurred in May/June and June/July in the Inner Channel. Both sub regions had a similar standing crop of phytoplankton, but the annual primary production in the Inner Channel was only 4% of that in the Outer Channel due to rapid light attenuation and the rate of vertical mixing in the turbid waters of the Inner Channel. A further study concluded that advection and dispersion by currents determined the phytoplankton concentration in the Inner Channel rather than local production. Ref. 19.254 suggests that production of microphytobenthos (MPB) on the exposed inter-tidal flats is a major source of primary production in the Inner Channel that may exceed phytoplankton production and that resuspended MPB could be a significant contributor to measured chlorophyll a values. This same study calculated that MPB primary production on the intertidal flats was approximately 33g $C.m^{-2}.y^{-1}$.

19.4.12 The relative importance of different production sources can best be appreciated by considering measurements of Total Particulate Carbon (TPC) in the Inner Channel in July of 2,800mg $C.m^{-3}$, of which 107mg $C.m^{-3}$ was 'phytoplankton' (calculated from chlorophyll a measurements) and 2.8mg $C.m^{-3}$ was zooplankton (Ref. 19.253). At its July peak the zooplankton stock was 50mg $C.m^{-2}$ (2.8 $C.m^{-3}$ x mean depth of 18m) compared with typical values from a thermally stratified Celtic sea site of 1000 to 3000mg $C.m^{-2}$ and 700mg $C.m^{-2}$ in the Outer Channel. Ref. 19.253 concluded that the majority of the TPC and chlorophyll a was allochthonous in origin, i.e. detritus mostly of a terrestrial origin, and that the low values of phytoplankton and zooplankton demonstrated the minor role that the plankton plays in this sub region.

c) Zooplankton

19.4.13 The limitation of primary production due to elevated turbidity levels within the Bridgwater Bay area has the potential to reduce production of any zooplankton which feed on these microscopic plants (Refs. 19.86-88). Estuarine zooplankton, however, are primarily detritivores and it is considered that the main factor limiting zooplankton growth within this system is the need to process high levels of solids for relatively little gain.

19.4.14 Surveys of zooplankton were carried out by the Institute for Marine Environmental Research (IMER) between 1971 and 1981 (Refs. 19.89, 19.90 and 19.253). Ref. 19.89 describes the species assemblages, biomass and seasonal cycles of zooplankton in the Bristol Channel and Severn Estuary. These assemblages were typical of estuaries in northern latitudes, both in terms of their abundance and species composition. Species diversity of the zooplankton in the Bristol Channel, and in the Severn Estuary in particular, has been reported as being relatively low when compared to other coastal shelf areas around the UK (Ref. 19.90) but such limited diversity is typical of the estuaries themselves, where only relatively few species occur although sometimes in very high numbers.

19.4.15 The holoplankton of the Inner Bristol Channel and Bridgwater Bay is dominated by calanoid copepods, primarily those of the genera *Acartia* and *Eurytemora* (Ref. 19.89). The dominant species are the estuarine resident species *Eurytemora affinis* together with the seasonal estuarine resident *Acartia bifilosa*, although *Centropages hamatus* may also occur in moderate densities as well as, less frequently, *Pseudocalanus*. These copepods have been recorded in maximum densities in July following increases in abundance in March, April and May (Refs. 19.89 and 19.90). These same references record the fact that mysids (particularly *Schistomysis spiritus*) also constitute a large part of the total zooplankton biomass in summer (approximately 80%). Meroplankton are generally only present in low numbers in the Bridgwater Bay area (Ref. 19.89).

19.4.16 Salinity and temperature are understood to be important environmental variables affecting zooplankton distribution; the powerful tidal movements also have a considerable influence (Ref. 19.90). When considering the biomass of zooplankton in the Bristol Channel and Severn Estuary, Williams, 1984 (Ref. 19.89) identified a gradient from higher biomass at the seaward extent to lower values further upstream. This gradient was more pronounced in spring for the omnivores and in summer for the carnivores (reflecting the pattern of food availability). Peaks in biomass in the omnivorous zooplankton occurred throughout the year. Carnivorous species such as *Sagitta* and *Pleurobrachia* tended to be more abundant in the latter half of the year.

19.4.17 Qualitative entrainment sampling for zooplankton from HPB has been undertaken monthly for the last 35 years (Ref. 19.91). Ref. 19.259 provides details of the community structure from samples collected between August 1994 and July 1995. Numerically the most abundant zooplankton in the HPB samples were copepods dominated by *Acartia* spp (>50% by number), followed by mysids dominated by *Schistomysis spiritus.*

19.4.18 A total of 43 taxa were recorded during the period between April 2007 and June 2009. The most abundant group of macrozooplankton collected over this sampling period was mysid shrimps, which form a significant component of the diet of pelagic and demersal fish in this area. The mysids showed a strong seasonal pattern in abundance and species-complement in relation to the salinity-cycle, with lowest numbers occurring in January and February. A notable feature of this long-term dataset has been the significant increase in mysid abundance over the last 30 years: peak mysid abundance is now almost six times the level observed in the 1980s and 1990s (peak of approximately 3000 individuals in 2008 HPB samples in comparison with maximum of 500 individuals per sample in the 1980s and 1990s). Since the commencement of sampling, the mysid assemblage has been dominated by three species, *Schistomysis spiritus, Mesopodopsis slabberi* and to a lesser extent *Gastrosaccus spinifer*.

d) Ichythyoplankton

19.4.19 Zooplankton surveys conducted as part of the BEEMS programme were dedicated towards gaining an understanding of ichthyoplankton (fish larvae and egg) abundance and distribution. Overall, fish eggs from nine taxa were recorded (anchovy *(Engraulis encrasicolus)*, rocklings (Lotidae), gurnard (Triglidae), European sea bass *(Dicentrarchus labrax)*, Dover sole *(Solea solea)*, solonette *(Buglossidium luteum)*, mackerel *(Scomber scombrus)*, pilchard *(Sardina pilchardus)*, scaldfish *(Arnoglossus laterna)*) and some unidentified eggs were also collected in June 2008 and May 2009. Larvae of herring (Clupeidae), sprat *(Sprattus sprattus)*, sandeel (Ammodytidae), dragonet (Callionymidae), gobies (Gobiidae), Dover sole, European sea bass and solenette were also recorded (Ref. 19.33). The majority of ichthyoplankton were caught during the May 2009 surveys.

19.4.20 The most frequently recorded component of the ichthyoplankton was anchovy eggs which were collected at over 30% of the stations, with a maximum abundance of 6.51 eggs per m^2 (where abundance is standardised to the number of units under $1m^2$ of sea surface). Historically, anchovy have been rarely reported in the area and its presence here (in particular, the presence of eggs, indicating local spawning) might indicate an increased northward distribution of the species from southern waters. The second most abundant ichthyoplankton group was goby larvae; goby eggs were also collected at 35% of the stations, with a maximum abundance of 2.46 eggs per m^2 (Ref. 19.33). High densities of sea bass larvae were recorded during the May 2009 surveys whereas previously these had not been recorded. With the possible exception of anchovy, the ichthyoplankton species identified during these surveys are not uncommon in coastal or inshore waters and did not have distributions which could be construed as unusual.

e) Subtidal Benthic Infauna

19.4.21 The benthic fauna of the Inner Bristol Channel and Severn Estuary is generally regarded as being an impoverished assemblage dominated by opportunistic species, as a result of the high instability of the sediments (Refs 19.92 and 19.93). The authors of Ref. 19.94 surveyed the bottom fauna at 155 stations in the Bristol Channel from Lundy Island to just above the Holm Islands, and found the area around Hinkley Point to have a reduced hard-bottom community owing to the effects of strong tidal scour. A more recent survey of the fauna of the deep-water channel and marginal areas of the Severn Estuary between Flatholm Island and King Pool, upstream of Hinkley Point, found the benthic fauna of *Sabellaria*-dominated seabed was impoverished when compared to similar habitats in the Bristol Channel and elsewhere in the British Isles (Ref. 19.95).

19.4.22 The recent BEEMS surveys, which sampled the benthos during five quarterly surveys in 2008 and 2009 (Refs. 19.28, 19.39, 19.40; sampling site locations are shown in **Figure 19.5**), found a total of 47 macroinfaunal taxa including *Sabellaria* spp., together with three hyperbenthic taxa (*Crangon crangon* and mysids) and sessile epifauna (bryozoans, hydroids, barnacles). Overall species richness and individual abundance were both very low, and in each of the quarterly surveys, several stations had no macrofauna in any of the samples taken (27% of some 300 grab samples taken across the study period contained no fauna at all). Where fauna were present, on average only 3 individuals were found per $0.1m^2$ sample – and the average number of taxa per $0.1m^2$ sample was <2.

19.4.23 The total numbers of taxa recorded across a single survey were higher in February, June and August of 2008 (23 to 26 taxa) than in the 2008-2009 winter (11 to 15 taxa), while densities of individuals were typically lowest in both winter periods.

19.4.24 Only nine species contributed significantly to this sparse assemblage across the whole study period. The bivalve molluscs *Macoma balthica* (mean abundance 22 individuals per m^2) and *Nucula nucleus* (32 individuals per m^2) dominated in terms of abundance and biomass and, together with the cumacean *Diastylis rathkei* (5.8 individuals per m^2), in terms of occurrence. *Macoma* was found primarily at only two sampling locations directly in front of HPA and HPB, with one observed density of 420 individuals per m^2, but elsewhere was rare. Three species of polychaete characteristic of muddy sands, *Nephtys hombergii* (mean 5.9 individuals per m^2), *Scoloplos armiger* (4.4 individuals per m^2) and *Aphelochaeta marioni* (1.6 individuals per m^2), were the only other taxa recorded in all quarters. The oligochaete *Tubificoides amplivasatus* was recorded in most quarters, while the gastropod *Hydrobia ulvae*, the amphipod *Harpinia pectinata* and the polychaete *Sabellaria alveolata* were the only other taxa to occur at an average density of one individual per m^2 or more, and in the case of the last three in only one quarter (survey).

19.4.25 In general, both macrofaunal species number and densities were found to be highest in nearshore locations and were lower at the sampling sites further offshore, but the data were too sparse to demonstrate any relationship between the “community” and the substratum type.

19.4.26 These low densities represent a high degree of impoverishment and reflect the dynamic conditions of the estuary. Surveys undertaken in autumn 2008 and spring 2009, using 0.5mm mesh sieving rather than the more usual 1.0mm mesh, identified a further component of the fauna. These surveys found that the oligochaete *Tubificoides amplivasatus* (potentially a significant food resource for fish and invertebrates) was the numerically dominant species, with average densities ranging between 200 individuals per m^2 (offshore, April 2009) to 2000 individuals per m^2 (nearshore, May 2009). Otherwise, the results confirmed that the benthic assemblages across the survey area were characterised by the same few dominant species, all at relatively low densities compared with populations elsewhere in the UK, but without any particular distinction in densities between nearshore and offshore stations.

19.4.27 Owing to the impoverished assemblages that make up the Hinkley subtidal benthos, attempts at multivariate analyses in order to explore pattern and its potential drivers tend to provide unsatisfactory results. Equally, it is difficult to attempt to correlate the assemblages that have been observed with the UK biotope classification (Ref. 19.96), although the assemblage present is closest to SS.SMu.SMuVS.NhomTubi *Nephtys hombergii* and *Tubificoides* spp. in variable salinity infralittoral soft mud.

f) Sabellaria

19.4.28 There are two species of the polychaete genus *Sabellaria* (‘honeycomb-reef worms’) found in the UK. *Sabellaria alveolata* is a Lusitanian species, commonly occurring in the low littoral but also extending into the sublittoral to depths of 20m or more; *Sabellaria spinulosa* is a colder water species, predominantly infralittoral/sublittoral, and mainly distributed off northern and eastern shores of the UK. Both species build sandy tubes; in the case of *S. alveolata* these tubes are normally colonial, and aggregate to form what can be substantial reef structures; *S. spinulosa* tubes are normally built horizontally on hard substrata, but may also aggregate to form reef-like structures (e.g. off the Wash, Eastern England).

19.4.29 Although these species have no statutory protection, their larger aggregations of tubes are considered to be biogenic reefs, consistent with the priority habitat ‘reefs’ in the sense of Annex 1 of the Habitats and Species Directive and as such *Sabellaria* is a qualifying feature of the Severn Estuary SAC. Biogenic reefs have a number of ecosystem functions: they may stabilise a sedimentary environment, provide hard substratum to which other sessile organisms may attach, can provide additional crevicial habitat, and can alter local hydrodynamics, leading to deposition or erosion of fine sediment particles and their associated organic matter (Ref. 19.97). These structures are therefore considered of some conservation importance under the UK Biodiversity Action Plan (Ref. 19.244).

19.4.30 A *Sabellaria* reef has been defined arbitrarily as a dense aggregation of worms (over 1000 per m^2), generally forming a thick (2cm or more) crust of tubes, covering an area generally exceeding $25m^2$, although patchily (Ref. 19.98). In practice, even the largest *S. alveolata* reefs are more patchy than extensive.

19.4.31 *S. alveolata* predominates on hard substrata both littorally and sublittorally in the Severn Estuary and Bristol Channel. The recent offshore surveys recorded *S. alveolata* (and possibly, but rarely, *S. spinulosa*) but only sparsely and on few occasions. Despite the recorded occurrence of sublittoral *S. alveolata* reefs in this vicinity (e.g. Refs. 19.2, 19.94 and 19.99), no aggregations of reef size were found in the recent Hinkley Point offshore surveys, although remote sensing surveys gave some signals which might suggest some *Sabellaria* reefs in the area.

19.4.32 *S. alveolata* reefs are common on the lower shore along the rock platform fronting HPA, up to 2m above Mean Low Water Spring (MLWS), and within the midfield dispersion pattern of HPB thermal plume. Surveys carried out locally on the intertidal area at Hinkley (Refs. 19.8, 19.11, and 19.12) found that the reefs growing within the flow of the cooling water discharge from the power station were substantially larger, commonly greater than 15cm in height and over 1m across, than those recorded elsewhere along this shore. These larger reef-units also supported a denser and more diverse associated fauna. Tube-building in *S. alveolata* has been shown to be greatest above 15ºC, lower at 10ºC and absent at 5ºC (Yves Gruet, pers. comm.). The greater size of the outfall reefs at Hinkley is attributed to continued growth of the worm (and thus its tubes) during winter periods, while reefs elsewhere were suppressed or even killed by winter frosts.

19.4.33 Recent surveys (Ref. 19.55) have confirmed the persistence of the *Sabellaria* reefs within the lower intertidal areas off Hinkley Point. Based on the classifications summarized in Ref. 19.96 these reef areas are considered to be generally of 'reduced quality', with some areas of 'moderate quality'.

g) Subtidal Epibenthos and Hyperbenthos

19.4.34 The epifauna is made up of species living on (above) the surface of the substratum, or living on other species which are themselves living on or protruding through that surface. The hyperbenthos includes those species living just above the sediment surface. This group includes the mobile epifauna, such as bottom-living shrimps, and prawns. *S. alveolata* is a member of the epifauna, and offers substratum to other sessile epifaunal species including bryozoans and hydroids; this species has largely been dealt with above.

19.4.35 Results from epifaunal surveys (Ref. 19.33) show the area in the vicinity of Hinkley Point to be supporting only a limited diversity of larger, mobile benthic invertebrates, with just 77 benthic invertebrate taxa identified over the three years of survey work. The Crustacea were the most diverse phyla found during the survey programme, accounting for 32-42% of all species recorded. Mollusca and Cnidaria (primarily colonial hydroids) were also key components of the community. The bivalve *Nucula nucleus* was the most abundant species observed, accounting for >38% of all individuals observed. Other key species observed were the cumacean *Diastylis rathkei* and the bivalve *Macoma balthica*.

19.4.36 The epibenthic invertebrate community varied spatially across the sampling area with significant differences in assemblage patterns apparent between nearshore and offshore communities. Assemblage patterns were also closely correlated to substratum, with diversity and abundance of species higher in the soft sedimentary environments in the centre of the survey area and the east of Hinkley Point, compared with communities on the coarse and mixed substrata to the west, which were typically less diverse and abundant. No clear temporal trends could be identified from the survey data.

19.4.37 The dominant species was the common shrimp, *Crangon crangon*, the most important prey species in this region for demersal and benthic fish (and various bird species); *C. crangon* was taken in every survey, and at more stations than any other species. *Crangon* is of some local commercial importance owing to the artisanal fishery on Stert Flats: studies in the 1980s (Ref. 19.100) showed that the Bristol Channel and Severn Estuary population size was of the order of 10^7 to 10^9 individuals, depending upon season.

19.4.38 The other dominant species were also decapod crustaceans, the swimming crab *(Liocarcinus holsatus)* and the pink shrimp *(Pandalus montagui)* being most common. Hermit crabs *(Pagurus bernhardus)* and edible whelks *(Buccinum undatum)* were occasionally present, and most other species incidental.

19.4.39 Impingement and entrainment studies carried out at HPB over the last 35 years have provided extensive information on the local mobile epifauna. The common shrimp *C. crangon* has been the most commonly caught species and has had the greatest abundances (Ref. 19.101). The *Crangon* population is known to remain relatively stable (although there was a year of exceptional recruitment in 2002), although it also exhibits trends both in relation to average water temperature from January to August, and with the Winter North Atlantic Oscillation Index (Ref. 19.102). The abundance of this species has shown seasonality in relation both to recruitment and to the seasonal salinity regime at Hinkley (Ref. 19.103).

19.4.40 Other common species caught at HPB intake screens included the common prawn *(Palaemon serratus)*, and the pink shrimp, which have both shown a clear gradual trend of increasing abundance locally (Ref. 19.102) as well as similar patterns of seasonality in relation to salinity (Ref. 19.103).

h) Intertidal Flora and Fauna

19.4.41 Hinkley Point is fronted by an area of cross-shore rock platforms. That area is flanked by further expanses of intertidal rock, with occasional pockets of sediment, extend to the west. To the east lie the intertidal mudflats of Bridgwater Bay and the saltmarsh areas lining the estuary of the River Parrett.

19.4.42 Given the extreme turbidity regime, the soft-shore microphytobenthos, the macroflora of the intertidal rocky areas and the saltmarshes provide the dominant contribution to primary production within the system (Ref. 19.104). In addition, subtidal benthic assemblages in the Severn Estuary and Inner Bristol Channel generally show low density and diversity (Refs. 19.1 and 19.28). Ecological activity in the Severn Estuary is thus disproportionately concentrated in the intertidal zone.

19.4.43 A number of surveys of the intertidal area at Hinkley Point were undertaken between 1982 and 2001, including environmental impact assessment (EIA) surveys for the proposed CEGB nuclear power station project (Ref. 19.10 and 19.105), and surveys investigating the presence of the mussel *(Mytilus edulis)* (Refs. 19.4, 19.11, 19.13 and 19.106). The results of these surveys indicated a stable community with low faunal and floral diversity.

19.4.44 Habitat and biotope mapping has been completed for this intertidal area (Ref. 19.55) and the mapping of the area fronting the HPC site is shown in **Figures 19.8** to **10**.

19.4.45 The rock platform at Hinkley Point is made up of relatively thin strata of mudstone and limestone which dip some 5° seaward. Erosion of the softer mudstone and progressive fragmentation of the harder limestone has resulted in a series of seaward-inclined limestone pavement platform ledges, running approximately parallel to the shoreline. The upper boundaries of these ledges form small “cliffs” or steps, up to 1m high, behind which water-filled gullies are retained over most or all of the tidal cycle. The angle of strike of the beds fronting the HPC Development Site is such that there is a clear trend in longshore drainage across these platforms whilst the tide is out, from east to west.

19.4.46 The limestone platforms support dense beds of fucoid algae, with a typical zonation from *Pelvetia canaliculata* at the upper-shore, through *Fucus spiralis* and *F. vesiculosus* to *F. serratus* and *Ascophylum niodosum* in the mid- to lower-shore. Hybrids of the *Fucus* species are present, and *Vertebrata lanosa* is common on the *Ascophyllum*. Macroalgae are absent below MLWS, owing to the lack of light in the highly-turbid waters, a condition which extends along this coastline from Kilve to

Sharpness (Refs. 19.3 and 19.107). The top of the shore supports green algae, notably *Ulva intestinalis*, *Ulva prolifera*, *Blidingia minima*, and *Blidingia marginata*.

19.4.47 The area supports a particularly impoverished red-algal flora (Ref. 19.3). There are, however, locally important red-algal communities and one such provides a distinctive feature on the Hinkley frontage: a series of *Corallina* 'run-offs' or 'swards' (Ref. 19.7 and 19.9). These coralline turf habitats have developed on the cross-shore rock platforms, where breaches in the upslope limestone scarps allow water to flow from these longshore drainage lines down across the relatively flat limestone pavement itself, locally maintaining a constant shallowly wetted area whilst the tide is out. A turf of *Corallina* forms dense carpets constrained entirely within the boundaries of these flows (see **Figure 19.11**). The position of these turf run-offs in the intertidal areas local to Hinkley Point has remained stable with time, as they are defined by the shore topography. The annual green algae *Ulva lactuca* can also be found around the margins of these coralline turf areas, as is *Fucus serratus* (Ref. 19.3 and 19.13).

19.4.48 Particularly extensive swards of *Corallina* are to be found adjacent to Hinkley Point and at a locale 3km east of Watchet; the *Corallina* swards found along this rocky intertidal area are thus locally unusual features. These swards provide a refuge habitat that harbours greater diversity than the surrounding rock, in much the same way as *Sabellaria* reefs. As such, these habitats are functionally important and considered worthy of special consideration in the assessment process. The *Corallina* run-offs at Hinkley were found to provide habitat for 38 species, including several which have not been recorded elsewhere in the locality, such as the isopod *Jaera praehirsuta*, the pycnogonid *Anoplodactylus pygmaeus*, and the polychaete *Platynereis dumerilii* (Refs. 19.7 and 19.9). In conservation terms, these mats and their associated communities can be considered as one of the more important intertidal habitats within the region (Ref. 19.3). It has been suggested that these features form part of the 'red algal turf' biotope and are recognized as nationally scarce, and have been designated as a notable community of the hard substrate habitat sub-feature of the SAC (Ref. 19.30).

19.4.49 The other distinctive and important habitat within the intertidal zone at Hinkley Point is that provided by the consolidated agglomerations of *Sabellaria alveolata* tubes, in some areas forming low or moderate grade reefs (as described earlier within this Chapter) – see **Figure 19.11**. Other species that have been found to be significant locally include barnacles, limpets, periwinkles, top shells, dog whelks and anemones, whilst the authors of Ref. 19.13 also noted the presence of rock-boring piddocks *(Pholas dactylus)*.

19.4.50 The area has a very low mussel population (maximum of ten individuals recorded in any one survey) with no naturally occurring, breeding populations of *Mytilus edulis* in the area (Ref. 19.6). When mussels have been found, they have always been in poor condition with low growth rates, and this has been attributed to the high turbidity providing a very low scope for growth for such filter feeding species.

19.4.51 Wide rock pool areas are present on the shore and between the limestone scarp ledges, but, owing to the high turbidity of the water, and the tidally driven cycles of deposition and re-suspension of muds within them, are either poorly colonized or un-colonized. Under-boulder communities are similarly sparse or absent, although shore crabs *(Carcinus maenas)* are present, particularly amongst the low-shore

Sabellaria reefs, where they are a major predator of *S. alveolata* (fragmenting and destroying the reef-units).

19.4.52 Areas of intertidal soft sediment are found predominantly to the east of the Point. The author of Ref. 19.5 surveyed the littoral fine-mud substratum immediately to the east of Hinkley Point (the "Submarine Forest"). The dominant macrofaunal species in that area were the bivalve *Macoma balthica* and the polychaete worm *Nepthys hombergii*. Juvenile gastropods and small spionid polychaetes were also frequent. Perhaps owing to the intense predation pressure on these species, from birds during low tide and from aquatic predators such as fish and decapod crustaceans (particularly *C. crangon*) when covered by the tide, individuals of these species are commonly small and fast maturing, as their survival to reproduction is highly constrained.

19.4.53 Recent surveys (Ref. 19.23) examined 40 soft-sediment sampling stations across the intertidal zone between Brean Down and Hinkley Point (see **Figure 19.5**). A total of 40 macrofaunal taxa were recorded, with a mean of only 6.6 taxa per station. The areas with the highest macrofaunal densities were generally found along the higher-shore regions of Berrow Flats and near the mouth of the River Parrett. Similarly, areas with the greatest macrofaunal biomass were along the upper shore region of Brean Down and Berrow Flats and towards the west of Stert Flats. Neither elevation nor median sediment grain size correlated with macrofaunal biomass or numbers of individuals. Biomass was dominated by three taxa: the Baltic tellin (*Macoma balthica* – 63%), ragworm (*Hediste diversicolor* – 15%) and the laver spire-shell (*Hydrobia ulvae* – 8%). The most widely distributed taxa were *H. ulvae* and *M. balthica* (each observed at 36 stations), with *M. balthica* more dominant on the mid to lower-shore, and ragworm more dominant on the upper shore. Average numbers of *Macoma balthica* over the surveys were 492 individuals per m^2. These species, particularly the tellin, represent the main food-resource for shore-birds and demersal fish and decapods.

19.4.54 The only other macrofaunal species of notable occurrence were the spionid polychaete *Pygospio elegans*, the amphipod *Corophium volutator*, and, at two sites on the south side of the River Parrett, the cleaner-sand-associated amphipod *Bathyporeia pelagica*.

19.4.55 The presence of mobile invertebrate species and the level of fish usage over the soft intertidal areas to the east of Hinkley Point intertidal surveys of the Hinkley Point frontage have been assessed using seine and fyke nets (Ref. 19.61). The commonest invertebrate species recorded were the shrimp *C. crangon*, the prawns *Palaemon elegans*, *Palaemon longirostris* and *Palaemonetes varians* and the mysids *Mesopodopsis slabberi*, *Neomysis integer* and *Schistomysis spiritus*. All of these are important prey species for the fish populations within the estuary.

19.4.56 Unicellular algae are the dominant source of primary production locally. Ref. 19.80 describes the 'intertidal epipelic (sediment surface) floral assemblages' (otherwise known as 'microphytobenthos') from samples collected between 1990 and 1991. Diatoms comprised over 95% of the living cells in most of these samples and occasionally the non-flagellated euglenoid *Euglena deses* was also abundant. Over 60 diatom taxa were identified with 15 to 20 of these recorded regularly throughout the survey period.

19.4.57 There are large fringes of saltmarsh in the estuary. *Spartina* spp. are particularly common and are abundant in Bridgwater Bay NNR (especially around the mouth of the River Parrett); *Spartina anglica* was planted in that area in 1929 as a flood defence measure. In Bridgwater Bay, this particular species now covers an area 3km long and 0.3 to 0.45km wide with an area of approximately 120ha (Ref. 19.108). The total area of saltmarsh habitat in the Severn Estuary as a whole is reported as 1521ha, the majority of which (75%) occurs on the English side (Ref. 19.3). The saltmarshes are regarded as significant nature conservation features and contribute to the SPA, Ramsar and SAC designations.

i) Coastal Squeeze

19.4.58 Loss and gain of intertidal area due to relative sea level rise, coastal squeeze and the possible responses within this particular area are discussed in several documents (see **Volume 2**, **Chapter 17**), although the quantitative estimates of the amounts involved are either missing, poorly explained or poorly defined. Several sources suggest that this will happen locally, without providing estimates. The description of Cell 11 within the current Shoreline Management Plan 2, which includes the Hinkley Point site, suggests that in the short-term (up to 2028) it will experience marginal erosion of 10-30% saltmarsh, although this depends on the evolution of the River Parrett (Ref. 19.109); the uncertainties in this estimate increase from 2058-2108.

19.4.59 Ref. 19.110 indicates an overall habitat loss of 1200ha from Land's End to St David's Head and a gain of >200ha but these values have not been broken down further for Severn Estuary. Lyn Jenkins (Environment Agency, unpubl.) gives a prediction for the Severn estuary of 700ha lost by 2026, 1300ha by 2056 and 2600ha by 2106 for sea level rise.

19.4.60 Ref. 19.111 emphasises that significant effects of sea level rise are likely on the European sites Severn Estuary SAC, SPA and Ramsar sites and that, as recognised by the Shoreline Management Plan 2, there will be the need for new seawalls thus exacerbating coastal squeeze, habitat loss and habitat fragmentation. That report suggests the general changes that are expected: saltmarshes and mud/sandflats will be reduced in the next two decades with a 7% decrease predicted for the whole Severn Estuary. With Bridgwater Bay potentially accreting, thus leading to a local extension of intertidal habitats, the wider intertidal loss may be minimal over the next two decades, but will then be followed by a 5-10% decrease over the next 50 years and 10-20% over the next century (Refs. 19.109, 19.110 and 19.111).

19.4.61 **Volume 2**, **Chapter 17** considers the likely change in the cross-shore profile fronting HPC, driven by relative sea level rise and down-cutting associated with both continuing erosion and dissolution of the limestone platforms. As distribution of both *Corallina* swards and *Sabellaria* reef are interlinked to the geomorphology of the area, then any long-term evolution in cross-shore profiles relative to tidal range will also lead to an alteration in the distribution of these species.

j) Predation by Waterfowl

19.4.62 A local 'assemblage of waterfowl species' is protected under the Severn Estuary SAC designation (Ref. 19.114), as a notable species sub-feature of the estuary feature. This assemblage is also included in the Severn Estuary SPA and Ramsar site designations (again see Ref. 19.114). The following key species are identified in the SPA and Ramsar designations:

- Bewick's swan *(Cygnus columbianus bewickii).*
- European white-fronted goose *(Anser albifrons albifrons).*
- Dunlin *(Calidris alpina alpina).*
- Redshank *(Tringa totanus).*
- Shelduck *(Tadorna tadorna).*
- Gadwall *(Anas strepera)*.

19.4.63 Curlew *(Numenius arquata)*, pintail *(Anas acuta)*, ringed plover *(Charadrius hiaticula)*, grey plover *(Pluvialis squatarola)*, Eurasian teal *(Anas crecca)*, lesser black-backed gull *(Larus fuscus)*, wigeon *(Anas penelope)*, pochard *(Aythya ferrina)*, spotted redshank *(Trynga erythropus)* and tufted duck *(Aythya fuligula)* are also included as components of the overall assemblage (Ref. 19.114).

19.4.64 It is beyond the remit of this chapter to provide an in-depth analysis of spatial and temporal patterns in the bird populations utilising the site; these issues are dealt with in **Volume 2**, **Chapter 20** Terrestrial Ecology and Ornithology. What is of interest here is the degree of dependency these species have on intertidal prey. Tidal flats are known elsewhere to be an important food resource for aquatic birds, which in temperate regions may remove 10-30% of macrofaunal biomass per year (Refs. 19.112 and 19.113).

19.4.65 Understanding the trophic relationships between components of an ecological system is important when attempting to predict the effects of marine operations, as changes in food sources may impact on consumers such as birds if they have particular food requirements. Thus, with an understanding that the thermal plume associated with HPC will extend across a part of the intertidal area of Bridgwater Bay, a functional investigation of the links between the Bridgwater Bay waterfowl assemblage and their potential intertidal food resource became necessary. A full description of the various allied studies that make up this functional assessment may be found in Ref. 19.14.

19.4.66 Information on the bird species frequenting Bridgwater Bay was extracted from local ornithology surveys and identification of the main intertidal-feeding species achieved by examination of their feeding preferences.

19.4.67 Bird count summaries were based on the 2002 to 2007 Wetland Bird Survey (WeBS) high tide Bridgwater Bay and October 2008 to March 2009 low tide western Bridgwater Bay core count data. The low water surveys recorded all wetland birds feeding or resting within the area of coastline or mudflats being surveyed, within two hours either side of the low tide. The mudflats to the east of Hinkley Point were surveyed from two fixed points, at Stert Flats and from Stolford. To the west of Hinkley Point, the coastline was walked from the bay near Lilstock to the west, to the boundary of Hinkley Point power station.

19.4.68 The existing dataset did not however provide all of the necessary information, as it lacked observations for September 2008; these were necessary to fully characterise the over wintering bird populations that feed on the mudflats outside of the breeding period. Thus, an additional September bird count dataset from surveys during 2010 was utilised to understand site usage in the month of September. Surveys were carried out from four observation points on Stert Flats, recording bird counts and behaviour. Surveys were conducted over six hours, allowing a description of changes or pattern in bird distribution across the tidal cycle.

19.4.69 Forty species were recorded as present in Bridgwater Bay during surveys undertaken in 2008, 2009 and September 2010; where 18 species accounted for 99% of all records. Four of the six SPA species were regularly recorded in the bay during 2008 and September 2010. European white-fronted geese and gadwall were not present over that period (although three or four gadwall have since been seen in the area; see **Volume 2**, **Chapter 20**). Three of the SPA species were commonly recorded (dunlin, redshank and shelduck), while a small number (no more than ten) of Bewick's swans were recorded in Stert Flats on two occasions in 2008. The swans were not observed feeding on the intertidal flats (**Table 19.10**).

Table 19.10: Commonly Encountered Bird Species Recorded as Feeding in Bridgwater Bay, ordered by dominance (from Ref. 19.51)

Common Name	Count	% of Total Count	Cumulative %
Dunlin	3602	45.8	45.8
Herring gull	677	8.6	54.3
Knot	602	7.6	62.0
Eurasian curlew	520	6.6	68.6
Common shelduck	509	6.5	75.1
Black-headed gull	435	5.5	80.6
Black-tailed godwit	375	4.8	85.3
Eurasian wigeon	316	4.0	89.3
Eurasian oystercatcher	188	2.4	91.7
Grey plover	116	1.5	93.2
Mallard	108	1.4	94.6
Northern lapwing	90	1.1	95.7
Northern pintail	77	1.0	96.7
Common redshank	65	0.8	97.5
Ruddy turnstone	38	0.5	98.0
Dark-bellied Brent goose	25	0.3	98.3
Ringed plover	18	0.2	98.6
Little egret	13	0.2	98.7
Meadow pipit	12	0.1	98.9

Note: Count represents the sum of bird counts per month, based on data from October 2008 to April 2009. SPA designation species are highlighted.

19.4.70 Information on the Stert Flats birds' feeding preferences comes mainly from the literature (see **Table 19.11**). Observations on feeding behaviour in other locations are not necessarily applicable to Bridgwater Bay, as species may have site-specific preferences. However, they can give a good general overview of the prey species likely to be consumed by the birds, especially if supported by site-specific information.

Table 19.11: Potential Prey of Regularly Occurring Bird Species in the Bridgwater Bay Intertidal Area (table adapted from Ref. 19.114)

Species	Common Name	Potential Prey	Notes	Important Intertidal Feeder?
SPA Species				
Calidris alpina	Dunlin	Small *Scrobicularia plana*, small *Macoma balthica*, *Hydrobia ulvae*, *Corophium volutator*, *Hediste diversicolor*, *Talitrus* spp, *Carcinus* spp		Yes
Tadorna tadorna	Shelduck	***Hydrobia ulvae***, ***Corophium volutator***, young ***Macoma balthica***, young *Mytilus edulis,* young *Cerastoderma edule, Hediste diversicolor,* Nematoda, Polychaeta, Nereididae, Copepoda, Ostracoda, Amphipoda, Mollusca, Tellinacea, Platyhelminthes, Coleoptera, Tipulidae	Feeds on small poly- and oligochaetes when *H.ulvae* in short supply	Yes
Tringa totanus	Redshank	*Mya* spp, *Scrobicularia plana*, *Macoma balthica*, *Hydrobia ulvae*, *Corophium volutator*, *Hediste diversicolor*, *Nephtys* spp,small *Carcinus maenas*, *Crangon crangon, Talitrus* spp		Yes
Cygnus columbianus bewickii	Bewick's swan (Tundra swan)	Seeds, fruits, leaves, roots, rhizomes and stems of aquatic plants grasses sedges, reeds	Intertidal resources are not the main food	
Anas strepera	Gadwall	Seeds, leaves, roots and stems of aquatic plants grasses and stoneworts	Intertidal resources are not the main food	

Species	Common Name	Potential Prey	Notes	Important Intertidal Feeder?
Common Species				
Larus argentatus	Herring gull	Fish, earthworms, crabs, molluscs, echinoderms or marine worms, adult birds, bird eggs and young, rodents, insects berries and tubers	Highly opportunistic diet, exploit almost any superabundant source of food, scavenger	?
Calidris canuta	Knot	*Mytilus edulis*, *Mya* spp, *Scrobicularia plana*, *Macoma balthica*, *Hydrobia ulvae*, *Hediste diversicolor*	Low knot populations have been attributed to low *Macoma* populations	Yes
Numenius arquata	Curlew	*Mya* spp, *Cerastoderma edule, Scrobicularia plana, Macoma balthica, Hediste diversicolor, Arenicola marina, Carcinus maenas,* *Skenea* spp, *Corophium volutator*, Nematoda, *Hydrobia ulvae*		Yes
Larus ridibundus	Black-headed gull	Aquatic and terrestrial insects, earthworms, molluscs, crustaceans, marine worms, fish, rodents agricultural grain	Highly omnivorous, shows scavenging behaviour	?
Limosa limosa	Black-tailed godwit	*Scrobicularia plana, Macoma balthica, Hediste diversicolor* Possibly also *Skenea* spp, *Corophium* spp, Nematoda, *Hydrobia ulvae*	Bridgwater Bay represents one of the most important sites in the country for this species	Yes
Anas penelope	Eurasian wigeon	Leaves, seeds, stems and root bulbs of pond weeds, fine grasses, horsetails and eelgrass, as well as algae	Herbivorous bird; animal material can however be taken incidentally	
Haematopus ostralegus	Oystercatcher	*Mytilus edulis*, *Mya* spp, *Cerastoderma edule, Scrobicularia plana, Macoma balthica, Hediste diversicolor, Arenicola marina, Carcinus maenas*		Yes
Pluviatilis squatarola	Grey plover	*Scrobicularia* spp, *Macoma balthica*, *Hydrobia ulvae*, *Hediste diversicolor*, *Arenicola marina*		Yes

Species	Common Name	Potential Prey	Notes	Important Intertidal Feeder?
Anas platyrhynchos	Mallard	Seeds and the vegetative parts of aquatic and terrestrial plants, terrestrial and aquatic invertebrates (insects, molluscs, crustaceans, worms) and occasionally amphibians and fish	Omnivorous and opportunistic species, it shows preference for freshwater and brackish habitat	Unknown
Vatellus vatellus	Northern lapwing	Adult and larval insects, spiders, snails, earthworms	Intertidal resources are not the main food	
Anas acuta	Northern pintail	Algae, seeds, tubers, vegetative parts of aquatic plants, sedges, grasses, aquatic invertebrates (insects, molluscs and crustaceans), amphibians, small fish	Omnivorous and opportunistic	Unknown
Arenaria interpres	Turnstone	*Mytilus edulis*, *Mya* spp, *Scrobicularia* spp, *Macoma balthica*, *Hydrobia ulvae*, *Corophium volutator, Hediste diversicolor*		Yes
Branta bernicla	Dark-bellied Brent goose	Algae, seaweeds, other aquatic plants (e.g. *Zostera* spp, *Ruppia maritima*, *Spartina alterniflora*, *Salicornia* spp)	Mainly herbivorous but it may occasionally take animal matter	Unknown
Charadrius hiaticula	Ringed plover	*Hydrobia ulvae, Corophium volutator, Hediste diversicolor*		Yes
Egretta garzetta	Little egret	Mainly small fish, aquatic and terrestrial insects (e.g. beetles, dragonfly larvae, mole crickets and crickets), crustaceans (e.g. *Palaemonetes* spp., amphipods), amphibians, molluscs (e.g. snails and bivalves), spiders, worms, reptiles and small birds	Highly opportunistic feeder	Unknown
Anthus pratensis	Meadow Pipit	Insects (e.g. flies, beetles and moths) and spiders	Lives on open grassland, tundra, dunes	

Note: *Prey sources identified as being consumed by birds utilising Stert Flats, confirmed by microscopic or molecular faecal analysis (Ref. 19.54), are <u>underlined</u> and those confirmed by both the literature and faecal analyses are shown* ***in bold****. Information on non-mudflat feeding SPA species occurring in Bridgwater Bay is included for reference. Birds are listed in order of dominance at the site.*

19.4.71 Faecal analyses of birds utilising Stert Flats were conducted under the BEEMS programme during 2010 and early 2011 (see **Table 19.12**). Droppings were collected from the vicinity of bird flocks observed on Stert Flats in April, July, September and November 2010 and January 2011. Shelduck was mainly targeted (as it was both common and important in a conservation context) although other droppings were collected, where possible. The faeces were subject to microscopic and molecular analysis, to provide a qualitative estimate of the birds' diets. Microscopic analysis aimed to qualify all identifiable food sources, while molecular analyses aimed at *Hydrobia ulvae*, *Macoma balthica*, *Hediste diversicolor* and nematodes. Full details of the analyses are given in Ref. 19.45-48 and 19.54.

Table 19.12: Dietary Constituents of Birds Utilising Stert Flats during 2010 and early 2011, as Identified from Microscopic and Molecular Analyses of Bird Faeces (Ref. 19.54)

	April 2010		July 2010		November 2010[a]		January 2011	
	N = 4 Shelduck n = 2 Unknown species n = 2		N = 5 Shelduck n = 3 Godwit/curlew n = 2		N = 34 Shelduck n = 27 Knot/dunlin n = 3 (no microscopy) Unknown species n = 4 (no microscopy)		N = 20 Shelduck n = 20	
	Mic	Mol	Mic	Mol	Mic	Mol	Mic	Mol
Nematoda	b	(1)	e	(1)		(15)		(19)
Polychaeta								
Nereididae								
Hediste diversicolor		(2)		(1)		(5)		
Copepoda	c							
Ostracoda								
Amphipoda								
Corophium sp.			e					
Mollusca								
Tellinacea[f]								
Macoma balthica		(3)		(1)		(6)		(8)
Hydrobia ulvae	b	(2)	e	(2)		(10)		
Skenea sp			d					
Platyhelminthes	b							
Coleoptera	c							
Tipulidae								

Note: Surveys focussed on shelduck, although droppings from other species were collected, where possible. Table entries refer to shelduck droppings, unless otherwise stated.

Mic = microscopic analysis; Mol = molecular analysis; (#) Numbers in parentheses indicate the number of droppings in which the prey taxon was identified. Molecular analyses aimed only at *Macoma balthica, Hediste diversicolor, Hydrobia ulvae* and nematode.s and data are presented for the species overall.

[a] All samples subject to molecular analysis; only the first 20 were microscopically analysed.

[b] Only recorded in droppings from unknown species.

[c] Recorded in shelduck and unknown species droppings.

[d] Only recorded in godwit/curlew droppings.

[e] Recorded in shelduck and godwit/curlew droppings.

[f] Likely to be *Macoma balthica*, as no other Tellinacean recorded at Stert Flats during the BEEMS surveys.

19.4.72 Taken together, the analyses suggest that shelduck foraging on the flats have relatively diverse diets (Ref. 19.14). Molecular analysis (Ref. 19.54) confirms that local shelduck consume *Hydrobia ulvae*, *Macoma balthica*, *Hediste diversicolor* and nematodes. The molecular tools suggest uptake of additional prey species (the large number of bands detected on the analysis gels indicates the presence of other species) and microscopic examination of the droppings confirms polychaetes, platyhelminths, insects and a range of crustacea are consumed, as well as, potentially, microphytobenthos or macroalgae (some droppings were tinted green, though the source of this colouration is yet to be identified). Godwits/curlew (the droppings were recovered from a mixed godwit/curlew flock and could not be differentiated) on Stert Flats consume nematodes, *Corophium* species, *Hydrobia ulvae* and *Skenea*, another gastropod genus.

19.4.73 The qualitative nature of the analytical methods employed negates the possibility of ascertaining the precise extent to which the birds consume the various prey sources, and these analyses relate mainly to shelduck. However, the fact that the results support the food sources identified in the scientific literature increases confidence that the food preference is generally-sourced.

k) Distribution of Bird Prey Resources

19.4.74 Initial investigations of bird-invertebrate food web links focussed on the overall prey resource. This is a useful initial approach, when a variety of bird species are of interest and/or where specific feeding preferences are not known. In order to do this, a measure of food availability, 'Total Prey Availability' (TPA) (Ref. 19.29), was used. This measure describes the availability of the overall macro-infauna food resource, using the summed biomass of all species present at a particular location. In this respect, it takes no account of individual preferences for particular prey species, summarising the total potential food available to birds across the site.

19.4.75 TPA is calculated as: $TPA_z = E \int B_i$ where E = emersion time at station Z, and Bi = total biomass of all individual prey species > 1mm at station Z. Biomass was utilised, rather than the number of individual prey items, as this is more closely related to the energetic requirements of foraging birds (Re.19.116). Details of the calculations are given in Ref. 19.14 and the process is shown in **Figure 19.12**.

19.4.76 The total biomass of all potential prey items varied across the site. A trend of increasing biomass with increasing station elevation was visible for transects to the north of the Parrett estuary mouth, but this pattern was less clear to the south (**Figure 19.12 A**). After weighting biomass by emersion time, the importance of high shore sites was further increased (**Figure 19.12 B**) so that the final map of Stert Flats featured two potential feeding hotspots (**Figure 19.12 C, D**). One was located along the northern edge of the Flats close to the Parrett; the other along the southern shoreline of Stert Flats. Stolford Bay, to the east of Hinkley Point, may be a low-quality habitat for foraging birds, due to its combination of low macrofaunal biomass and shorter emersion time. Seasonal or inter-annual patterns of TPA have yet to be assessed for Bridgwater Bay. However, there was some degree of seasonal variability in the infaunal assemblages overall (although little evidence of significant short-term inter-annual variability).

19.4.77 While this approach gives a good overview of the potential food available to birds feeding on the mudflats, it does not differentiate between species likely to be consumed and those not favourable to the birds. Once further information on bird species utilising the site and understanding of their feeding preferences had been gathered, further investigations focussed on specific bird and prey species.

19.4.78 Inspection of the overall feeding preferences and infauna survey information suggests the main infauna species on Stert Flats known or likely to be consumed by the local birds are the Baltic tellin *(Macoma balthica)*, ragworm *(Hediste diversicolor)* and laver spire shell *(Hydrobia ulvae)* (see Refs. 19.23 and 19.62). They are all patchily distributed across the Bridgwater Bay intertidal flats, with *H. diversicolor* seeming to be more common in the upper shore and *M. balthica* in the lower – see **Figure 19.13**. Information on seasonal variability in these food sources was not available at the time of writing, although the mudflat fauna are known to be relatively stable between years. The predator and prey links are described in Section 19.6 ii).

l) Fish Assemblages

i. Introduction

19.4.79 This section provides information on the fish assemblages and associated resource (from a commercial perspective) of the Severn Estuary. The information covers all fish species which may potentially be impacted at some stage of their lifecycle by the marine works associated with HPC and thus includes the populations of fish which utilise the Severn Estuary as a migratory conduit between the sea and rivers flowing into the Severn Estuary, together with purely marine species which may utilise the estuary for the whole, or only part of their lifecycle.

19.4.80 When considering estuarine fish species, especially in connection with WFD requirements, it is important to understand the Ecological Use Functional Guild (EUFG) and to which guild each species belongs. The main ecological guilds for estuarine fish have recently been refined (Refs. 19.117, 19.118 and 19.119). The categories with their abbreviations are summarised below based on Ref. 19.120:

- *Estuarine Species* (ES): Can be resident (i.e. entire life cycle estuarine) or migrant (i.e. adults spawn in estuaries, marine larval phase, with juveniles returning to an estuary). Species with discrete populations in both estuarine and fully marine environments are included.
- *Marine Migrants* (MM): Adults live and spawn in marine environments, with juveniles frequently found in estuaries in large numbers. Juveniles can be opportunistic (i.e. can find suitable conditions within or outside estuaries), or dependant (i.e. require estuarine types of habitat).
- *Marine Stragglers* (MS): Live and breed in the marine environment. No estuarine habitat requirements but can enter lower reaches of estuaries. These stenohaline species generally avoid areas with salinities of less than 35‰, which can restrict up-estuary movement.
- *Anadromous* (A): Most growth occurs at sea, adults migrate from coastal marine areas to freshwaters to spawn (e.g. Atlantic salmon).

- *Catadromous* (C): Adults migrate from freshwaters to marine areas to spawn, but most growth occurs within freshwaters (e.g. European eel). Anadromous and catadromous species can be grouped together as diadromous species, i.e. migrating between marine and freshwater environments.
- *Freshwater Species* (FS): Those freshwater species found frequently, but in moderate numbers in estuaries and whose distribution only occasionally extends beyond areas of low salinity.

ii. Published Information

19.4.81 Numerous studies have been conducted examining fish assemblages within the Severn Estuary and the Bristol Channel (e.g. Ref. 19.121). As a result, information is available regarding species richness, assemblage composition and population dynamics of the Estuary and Channel (e.g. Refs. 19.122, 19.123 and 19.124), and a number of studies have been conducted to investigate the life history and migratory movement of specific species (e.g. Refs. 19.125-129).

19.4.82 No systematic targeted surveying or sampling of diadromous species is undertaken in the Estuary. Indeed, the paucity of diadromous species in long-term HPB intake records indicates that these species are highly dispersed across the Inner Bristol Channel in the Estuary, and can only be sampled in meaningful numbers when aggregated for reproduction in rivers.

19.4.83 Various data sources exist for diadromous species. Due to the high recreational, commercial and conservation value of salmon, a systematic monitoring framework exists for determining the status of various salmon fisheries. Data from rod catches and in some instances fish counters are used to estimate total run size, annually, on a river-by-river basis. The population size is then expressed in terms of the percentage of a conservation limit. The conservation limit is the number of salmon required to fully populate the river with juvenile salmon and is established for each river based largely on the area of suitable juvenile habitat present.

19.4.84 The recent SAC designation of the Wye, Usk and Tywi for shad and the Wye and Usk for sea and river lamprey under Annex I and Annex II of the Habitats Directive has created an impetus for monitoring these populations. Recent reports on lamprey (Ref. 19.130) and shad (Ref. 19.131) provide a basis for the assessment of these species. Both reports also discuss the results of surveys for these river populations in terms of the Severn Estuary. River specific datasets have been used to assess the status of riverine populations of species directly; the status of these species in the Estuary has been inferred largely from this data.

iii. The Hinkley Point B Severn Estuary Dataset (SEDS)

19.4.85 A comprehensive source of information regarding the abundance and species richness of fish in the Inner Bristol Channel is provided by the entrainment and impingement data collected at HPB since 1981. These long-term studies were instigated by the CEGB and since then monthly samples have systematically been taken and recorded. A long-term dataset of this nature is both uncommon and helpful. This dataset, currently maintained by Pisces Conservation with the sampling supported by the HPB operator and known of as the ‘Severn Estuary Dataset’

(SEDS), is primarily of use in assessing the status of purely marine species, but is also relevant to some diadaromous species, most notably the eel *(Anguilla anguilla)*.

19.4.86 A total of 83 estuarine and marine fish species have been recorded since these surveys began. Between April 2006 and March 2007, 29 fish species were recorded and 42 species were recorded between January and December 2008 (P. Henderson *pers. comm.*). Prior to the relatively low species richness of the 2007 catch, the number of species caught each year ranged from a low of 33 in 1982 to a high of 46 species in 1998 (Ref. 19.124).

19.4.87 The ten most abundant species recorded within SEDS are sprat *(Sprattus sprattus)*, whiting *(Merlangius merlangus)*, sand goby *(Pomatoschistus minutus)*, poor cod *(Trisopterus minutus)*, Dover sole *(Solea solea)*, pout *(Trisopterus luscus)*, common sea snail *(Liparis liparis)*, sea, bass *(Dicentrarchus labrax)*, flounder *(Platichthys flesus)* and dab *(Limanda limanda)*. Eight of these species are marine migrants with one marine straggler (dab), and one estuarine species (sand goby). In terms of abundance and diversity, marine migrants provided the greatest contribution to the fish assemblage in the Bristol Channel around Hinkley Point, and while marine straggler species richness is relatively high, they are frequently represented by a small number of individuals.

19.4.88 The routine monitoring undertaken at HPB indicates a gradual increase in the number of fish caught, related to increasing sea temperature and decreased salinity. Increasing abundance has been observed for species which are relatively close to their northern limits in the Bristol Channel such as sole and sea bass. Conversely, species relatively close to their southern limit in the Bristol Channel (i.e. relatively cold-water preferring species) e.g. dab and sea snail, have experienced a decline in abundance. An observed step change in the set of occasional visitor species (i.e. those species with a northern distribution limit at the Bristol Channel, or just south) has also been related to increased sea temperatures.

m) Fish and Fauna

19.4.89 The high tidal flows and turbidity observed locally create harsh environmental conditions for fauna, with the subtidal seabed areas being largely depauperate in terms of invertebrates. It is often claimed that this results in a unique fish community. However, SEDS shows that the fish community is broadly similar in structure to that of other estuaries in the south of England (Ref. 19.132).

19.4.90 The impoverished benthic fauna means that the fish productivity of the Bridgwater Bay area is primarily dependant upon mysids, amphipods, and euphausids, in addition to the brown shrimp, *C. crangon* (Ref. 19.133). Few fish complete their entire life cycle in the area. Rather, most marine species exploit the productivity of the intertidal areas as juveniles, moving in and out of the Severn Estuary and Inner Bristol Channel seasonally in response to limitations of low temperature and salinity in the latter part of winter. *C. crangon* is thought to be limited by low temperature and salinity. This winter period also coincides with periods of lower prey availability, as observed in mysids and carideans (Ref. 19.134) and *C. crangon,* which are also thought to be limited by low temperature and salinity. The variable chemical and physical conditions prevalent locally, combined with low levels of small zooplankton required by larval fish, render the area unsuitable for reproduction. Adult fish thus migrate offshore to waters with more stable physio-chemical conditions and abundance of planktonic prey. On maturation, many fish move offshore. Eggs and larvae then colonise local estuarine areas via tidal movements in the summer and autumn, although some post-larval fish such as sprat and transparent goby may enter in early spring.

19.4.91 Although not unique in terms of community structure, the authors of Ref. 19.128 conclude that the extent of sheltered estuarine habitats present in the Bristol Channel means that it should be considered amongst the most important nursery areas in Britain.

i. Marine Species

19.4.92 The broader fish population of the Severn Estuary and Bristol Channel is of a similar species composition to that of other estuaries and coastal regions in south-west England (Ref. 19.132), comprising approximately 80 species. The most common species are sprat and whiting, which are present at an order of magnitude higher by number than the next most abundant species, namely poor cod, sand goby, sea snail, pout and sole. For marine species, the estuary is primarily used as a nursery ground – the extensive areas of shallow marginal mudflat provide extensive juvenile feeding opportunities, but none of the species present completes its entire life cycle within the estuary. Studies indicate that the estuary holds a single, mobile fish community and relative abundances observed at HPB are representative of the estuary between Berkeley and Minehead.

19.4.93 Recent years have seen a marked increase in the abundance and species richness of fish in the Estuary (Refs. 19.123, 19.128), which may be as much as threefold the abundance observed in the early 1980s. Although this is partially attributable to improved water quality, as proposed by Ref. 19.123, increased temperature and decreased salinity appear to be the predominant environmental factors causing this increase. To some extent this may also reflect the large natural interannual variations commonly observed in some species, notably the pelagics.

ii. Seasonality of Fish Presence, Abundance and Migration

19.4.94 Numbers of individual fish present in the Estuary, indicated by captures at HPB, show a clear seasonal pattern with lowest numbers present in April and May rising steadily through the summer and autumn to a peak in December, where numbers decline in January, February and March. Species abundance follows a similar, albeit less pronounced, seasonality. Lowest annual monthly average species counts occur in May, June and July, peaks in abundance occur in October and November and then abundance declines throughout the remaining winter months and spring.

19.4.95 The HPB SEDS data reveals patterns in abundance. Peak abundances for the 13 most common species (which comprise 95.6% of the total number of individuals) are illustrated in **Figure 19.14**. This shows that most species exhibit a peak from September to January with all species being present for all or almost all of the year. However, it is also apparent that the area is used to an appreciable extent at all times of the year, with no clear period when all fish species are in low abundance.

19.4.96 The majority of fish species which occur in the area around Hinkley Point can be regarded as opportunists, which spawn elsewhere. The tolerance of lower salinities of many of these opportunists enables them to exploit the higher productivity and/or lower predation risk present locally.

19.4.97 Larvae of these species are tidally transported from offshore areas into the Inner Bristol Channel in the late summer and autumn. Upon metamorphosis these then colonise progressively upstream areas for a number of months utilising selective tidal stream transport. Broadly speaking, young of the year migrate seaward again in winter months, in response to reducing salinity (Ref. 19.122) and/or temperature. In the case of a number of fish species, in particular gadoids, the seaward migration is closely correlated with and in response to abundance of *C. crangon* (Ref. 19.122). This pattern of progressive colonisation in late summer and autumn, peak abundance in September and October, followed by reduced abundance due to seaward migration, can be seen for sand goby, sole, dab, pout and sea bass **Figure 19.14** with similar but delayed patterns occurring for poor cod whiting and grey mullet. Such species will undertake several years migrating between estuarine regions and the sea before maturing, when they adopt a purely offshore existence.

19.4.98 As discussed above, the benthic fauna of the local sea area is generally impoverished, with the shallower margins having a relatively high benthic productivity compared to the relatively barren, deeper areas (Ref. 19.36). The shallow margins are also the preferred habitat of crustacean prey, most notably the brown shrimp *(C. crangon)*.

19.4.99 Given the benthic conditions and the associated impoverishment, the very much more productive intertidal mudflats are of primary importance to fish. Of the four most abundant flatfish in the Severn, plaice and flounder utilise tidal transport to migrate shorewards with rising tides, feeding only on intertidal areas at high tide. Dab and sole, however, also utilise subtidal habitats for feeding (Ref. 19.135) although in the case of sole, ‘this year’ juvenile fish (0+) were found to prefer shallower regions (Ref. 19.136). This dependence on, and preference for, intertidal areas is related to prey abundance, notably *C. crangon* which is a key prey source (Ref. 19.133). The preference for sheltered shallow areas is also noted for gadoids (Ref. 19.122) and sea bass (Ref. 19.137). Ref. 19.243 confirms that the high intertidal offers optimal habitat for the early life stages of species such as sea bass.

19.4.100 Ten marine species found within the area are UK BAP species: cod *(Gadus morhua)*, herring *(Clupea harengus)*, plaice *(Pleuronectes platessa)*, sole *(S. solea)*, whiting *(Merlangius merlangus)*, blue whiting *(Micromesistius poutassou)*, hake *(Merluccius merluccius)*, horse mackerel *(Trachurus trachurus)*, ling *(Molva molva)* and saithe (*Pollachius virens*, coalfish). The entire estuarine fish community fulfils the Ramsar Criterion 8, which considers a wetland to be internationally important if it is an important source of prey for fishes, or is a spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend. These are inherent characteristics of estuaries and their associated fish communities (Ref. 19.135 and 19.138). Similarly, the area fulfils Criterion 7 in which a wetland is internationally important when supporting ‘"*a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity*". In having a total of just over 80 species, the estuary has a species complement comparable to other similar estuaries in Europe (Ref. 19.120 and 19.138).

19.4.101 Cod and the thornback ray are listed on the OSPAR List of Threatened and/or Declining Species and Habitats, however, thornback ray is only listed as under threat and/or in decline in the Greater North Sea and not in the Bristol Channel area. Cod is rated as vulnerable on the IUCN Red List of Threatened Species (Ref. 19.140).

iii. Diadromous Fish Species

19.4.102 Diadromous fish primarily utilise the Estuary for migration between their natal rivers - most notably the rivers Wye, Usk and Severn, and marine feeding grounds. Seasonal migratory utilisation of the Severn Estuary is described in **Table 19.13.** They may also use the estuary for feeding, e.g. in the case of juvenile shad, and river lamprey. The following paragraphs describe the migratory species associated with the Severn Estuary and associated rivers.

19.4.103 Seven diadromous fish species are known to migrate through the Severn Estuary; Atlantic salmon *(Salmo salar)*, twaite shad *(A. fallax)*, allis shad *(Alosa alosa)*, river lamprey *(L. fluviatilis)*, sea lamprey *(P. marinus)*, sea trout *(Salmo trutta)* and European eel *(Anguilla anguilla)*. Each of the species is anadromous with the exception of the catadromous eel. All of these species, apart from sea trout and eel, are listed as Annex II species under the EC Habitats Directive (92/43/EEC). In addition, Atlantic salmon and river lamprey are listed under Annex V of the Directive. All of these diadromous species are afforded protection as UK BAP priority species. Sea lamprey and salmon are also on the OSPAR List of Threatened and/or Declining Species and Habitats and both sea and river lamprey are on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (Ref. 19.140). Twaite shad is also on the IUCN Red List of Threatened Species and is listed under the Wildlife and Countryside Act 1983. All of the above mentioned species, except shad and Sea trout are protected under the Salmon and Freshwater Fisheries Act 1975 as amended by the Marine and Coastal Access Act, 2009.

19.4.104 All seven migratory species found within the estuary together form a qualifying feature of the Severn Estuary Ramsar site. Although each of these species is present, only twaite shad, river and sea lamprey are qualifying features of the SAC designation of the Severn Estuary.

19.4.105 At least two individuals of five of the seven migratory species have been recorded at the intake screens of HPB (the exceptions being allis shad and sea trout). In particular, relatively high numbers of juvenile twaite shad have been entrained at Hinkley Point with annual catches ranging from fewer than ten individuals in 1981, 1982, 1987, 1988, 1991 and 1993 to over 100 in 1989 (Ref. 19.141). Numbers of twaite shad impinged at Hinkley Point tend to peak in July and August.

iv. Estuarine Populations of Diadromous Species

19.4.106 In the context of estuarine fish species as a whole, other than eels, anadromous species of populations belonging to the adjacent rivers are rare, and infrequently recorded. For these migratory fish, the long-term data from HPB is of more limited value. Other data are required to assess these populations which, although rare, form the basis of the statutory nature conservation designations of the Estuary and the adjacent rivers. Given that anadromous fish populations are more amenable to survey when aggregated in rivers of origin, river specific data is more meaningful due to each river representing a discrete management, (and for some species, biological) unit. Riverine survey data have been relied upon and the available data, as presented for individual species below, have been interpreted in the context of the Estuary.

19.4.107 Lamprey and shad surveys carried out on the rivers Wye and Usk provide an indication of the conservation conditions for these rivers (Ref. 19.130 and 19.131). In the absence of direct data, the Severn Estuary populations for these species can be inferred. Ref. 19.130 discusses the validity of inferring the health of estuary populations from the adjacent rivers, specifically in the context of the Severn Estuary. The main uncertainty lies in the extent to which other rivers (most notably the Severn) contribute to the estuarine population, and the health of these populations. If, as has been suggested, lamprey populations are less faithful to their river of birth and the Severn population is therefore a more homogenous population, then the status of the species in any one river (e.g. the Wye or the Usk) can be considered to be representative of the estuarine population as a whole. If this is not the case, the Usk and Wye together are likely to comprise a sufficiently large proportion of the Severn Estuary population to make the assumption nonetheless correct, as only a very small percentage of lamprey in the estuary will be derived from other rivers and retain some heterogeneity.

Table 19.13: Migratory Movements of Diadromous Species found within the Severn Estuary, showing Important Months and Directions of Movement

Species	↑/↓	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Salmon	↑			■	■	■	■	■	■	■			
Smolt	↓				■	■	■						
Sea trout	↑						■	■	■	■			
Shad	↑				■	■	■						
Shad (Juv.)	↓				■	■		■	■	■			
Sea Lamprey	↑	■				■	■	■					
S. Lamprey (Juv.)	↓										■	■	■
River Lamprey	↑	■		■	■				■	■	■	■	
R.Lamprey (Juv.)	↓	■	■	■	■	■					■	■	■
Eel	↓									■	■	■	
Elvers	↑				■	■	■	■	■	■			

v. Salmon

19.4.108 Adult salmon migrate upstream primarily from July to September, with fish migrating during this time being primarily one-sea-winter salmon. Adult salmon also migrate in earlier months of the year, and although inferior in number, these comprise higher numbers of multi-sea-winter salmon. Multi-sea-winter salmon, and those which migrate upstream in earlier months (traits partially genetically determined and co-related) are of higher conservation importance than salmon generally and have undergone disproportionately large declines. This is more pronounced in the River Wye stock than perhaps any other UK river. This is reflected in their being afforded a range of specific conservation measures of both a non-statutory and statutory nature (e.g. national spring-run salmon conservation byelaws).

19.4.109 Salmon smolts migrate downstream through the estuary towards marine feeding grounds between April and June. Available evidence suggests that salmon smolt migration is characterised by selective tidal stream transport on the ebb tide, near the water surface in the areas of strongest flow, and takes place during the night (Ref. 19.142). Ref. 19.142 suggests that smolts pass rapidly through the estuary and do not require a significant period of acclimation to saline conditions.

19.4.110 Adult salmon migration within estuaries is characterised by utilisation of tidal flows, and, prior to entry to freshwater, salmon may reside in estuaries for varying periods. Ref. 19.143 found this to vary between nine hours and 190 days in the Fowey Estuary. During this time, salmon move up and down estuaries, and progress upstream by making effective use of the flood tide and seeking refuge from outflowing tidal currents (ebb tides) by utilising more marginal, lower velocity parts of the Estuary (Ref. 19.141).

19.4.111 Residence time in estuaries is largely dependant on riverine flow and temperature, with high riverine flows and low temperatures resulting in relatively quick river entry, and low flows with delayed entry whereby salmon reside in the estuary, or return to sea. An important feature of delayed entry is that this results in lower likelihood of salmon entering the river (Ref. 19.144).

19.4.112 Atlantic salmon are considered to be in unfavourable condition within both the River Wye and Usk SACs. They are currently failing to meet their Conservation Limits (CLs) set by Salmon Action Plans on the Rivers Wye and Taff/Ely. Although there is some uncertainty, the Rivers Usk and Severn appear to be complying with their CL targets. Overall, it is likely that the estuary population is below the population sought by managers to maintain its conservation and fisheries objectives.

vi. Lampreys

19.4.113 Adult river lamprey are known to enter UK rivers generally in the late autumn, although, unlike sea lampreys which undertake more extensive marine migrations, river lamprey make more use of estuarine habitats throughout their marine phase (Ref. 19.145). Sea lamprey migrate through the estuary and enter rivers to spawn in the early spring.

19.4.114 Ref. 19.122 recorded peaks in abundance of downstream migrating juvenile river lamprey in the Severn Estuary between October and January.

19.4.115 The most recent condition assessment round in 2007 classified all UK SACs with the exception of the River Usk as unfavourable for river lamprey and all but the River Wye as unfavourable for sea lamprey. In the absence of a comprehensive understanding of the amount of available lamprey habitat within each of the rivers, the current conservation status assessment procedure does not enable an assessment of standing stock to be made, therefore precluding the derivation of a species population estimate. No estimates have been made of the number of returning adults or outmigrating transformers of river or sea lamprey within the tributary rivers of the Severn Estuary.

vii.Shads – Allis Shad and Twaite Shad

19.4.116 Adult shads enter the Severn Estuary between April and June on their way to spawn in the rivers Severn, Wye and Usk, with peak immigration occurring in May.

19.4.117 Young of the year shad colonise the estuary from rivers from July, until migrating seaward in autumn. Ref. 19.122 recorded maximum numbers of juvenile twaite shad in the Severn in August and September. Juveniles may also return to the estuary the following April to May before returning seaward again in the late summer. This indicates that the estuary is more than merely a migration route for shad, and that it is of importance as a feeding ground for juveniles.

19.4.118 Inferring status of twaite shad populations in the Estuary from the adjacent riverine populations leads to an uncertain conclusion. Although data comparable to that of Ref. 19.131 does not exist for the Severn, its status is thought to be improving. However, both twaite and allis shad are currently classified as being in unfavourable status for all of their designated rivers (Usk, Wye and Tywi). Few estimates of the stock sizes of twaite or allis shad within the Bristol Channel or the Severn Estuary's tributary rivers have been made and the current conservation status sampling protocol does not enable quantitative assessments of standing stock to be made. During the derivation of the UK BAP priority species list Miran Aprahamian (pers. comm.) estimated that the twaite shad populations in the UK totalled approximately 100,000 returning adults split between the Rivers Severn, Wye, Usk and Tywi as 20,000, 50,000, 20,000 and 10,000 individuals respectively.

viii. Eel

19.4.119 Eels are catadromous, reproducing in the sea, and migrating to freshwaters to undertake most of their feeding and growth. The Severn Estuary and its rivers constitute the largest eel fishery in the UK; constituting 95% of all glass eels (juveniles migrating towards freshwater) caught in England and Wales. The majority of upstream migration of elvers (juveniles) takes place between April and September inclusive although closer to tidal limits this may be concentrated within the months of April to July (Ref. 19.146). The same authors suggest that peak downstream runs of adult eels take place between September and November.

19.4.120 European eel is categorised as Critically Endangered on the IUCN Red List of Threatened Species. Eel are considered to be under threat and have seen a significant decline in stocks. The International Council for the Exploration of the Sea (ICES) state that the European eel stock is outside safe biological limits. In 2007, the European Community entered into force a Europe-wide recovery plan (Ref. 19.147) with implementation measures which began in 2009. In March 2009, eel was also added to the Convention on International Trade in Endangered Species (CITES) Appendix II list, which details species in which trade must be controlled. In January 2010, the Eels (England and Wales) Regulations 2009 (Statutory Instrument No. 3344) came into force to meet the European measure. The new Regulations provide for consideration of passage and screening for eels.

19.4.121 Eel Management Plans have been implemented for the Severn Catchment which aim to provide an escapement of silver eel biomass that is at least equal to 40% of the potential escapement to be expected in the absence of anthropogenic influence. It is currently estimated that an escapement rate of approximately 34% is being achieved (Ref. 19.148).

19.4.122 In addition, Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European Eel (the European Eel Regulation) requires that a system is in place to ensure that, by 2013, 60% of eels less than 12cm long, which are caught commercially each year, are used for restocking in suitable habitat. On the basis of an estimate that the glass eel/elver fishery on the River Severn takes 10% of the stock it has been estimated that the glass eel population was within the region of 3 million individuals in 2008.

19.4.123 Data from long-term monitoring at HPB indicates a long- term exponential decline in catches from the commencement of records in 1980. This trend is also evident in the recruitment of glass eels to Europe which has declined since the late 1970s by as much as 99%.

ix. Sea Trout

19.4.124 Sea trout share much of the of the Atlantic salmon's biology as well as having a similar life history. Key differences include a higher degree of repeat iteroparity in sea trout (i.e. individuals have a greater propensity to survive to undertake repeated spawnings), and sea trout undertake their marine phase in coastal waters rather than undertaking the more extensive marine migrations of salmon.

19.4.125 Adult sea trout generally enter rivers in South Wales and the south-west of England from June to September, with smaller numbers entering at other times of the year.

19.4.126 Studies have indicated that sea trout smolt migratory behaviour is similar to that of salmon, taking place between April and June, utilising selective transport by ebb tides primarily at night, near the water surface in the fastest moving part of the water column (Ref. 19.142).

19.4.127 Data from rod, putcher and net fisheries indicate that sea trout occur at much inferior numbers than salmon. This is in contrast with nearby rivers in South Wales, which have strong sea trout populations (*e.g.* Tywi and Teifi). This suggests that riverine and estuarine conditions within the Severn are inherently unfavourable to sea trout. Given that the marine phase of sea trout is more coastal and estuarine than salmon, it may be that the highly dynamic nature of the Severn does not offer suitable inshore habitat.

n) Offshore Fish Surveys

19.4.128 Recent offshore surveys in support of the environmental assessment process in Bridgwater Bay in the vicinity of Hinkley Point (Ref. 19.33 and **Figure 19.5**) have recorded a total of 15 species of fish (**Table 19.14**). All fish caught were less than 30cm in length. Overall, the species with the highest catch rate were greater sandeel *(Hyperoplus lanceolatus)*, solenette *(Buglossidium luteum)* and whiting. During the four surveys (one scoping and three quarterly surveys) no significant concentrations of finfish species, commercial or otherwise, were identified.

19.4.129 These 2m beam trawl did not catch a single individual of any species of prime conservation or ecological concern, such as eel, salmonids (salmon and sea trout), smelt, and shad. However, Ref. 19.33 notes that the River Parrett, which discharges into Bridgwater Bay east of the HPC Development Site, historically had an eel population that was once heavily fished, with an estimated 10,000 eels per night in the river at peak migration times. Data collected by the Environment Agency for the period 1990 to 2006 indicate a general decline in eel density on the Parrett since the 1990s with little recruitment of small eel into the river. In 1992 maximum densities of up to 100 individuals per $100m^{-2}$ were recorded with this decreasing to below approximately 20 individuals per $100m^{-2}$ in 2006. Current European eel populations are depleted, and the evidence available suggests it is likely that only a small fraction of the historical eel run now takes place.

Table 19.14: Catch of Fish by 2m Beam Trawl (tows standardised to $1000m^2$) (Ref. 19.33)

Species	Q2/08 (Jun)	Q3/08 (Aug)	Q4/08 (Nov)	Q2/09 (May)
Dab	0	2.3	12.7	0
Five bearded rockling	1.8	0	0	0
Four bearded rockling	0.8	0	0	0
Greater sandeel	51.7	23.9	35.4	0
Grey gurnard	1.4	0	0	0
Herring	0	0	6	1.2
Lesser sandeel	0	0	29.4	0
Montague's sea snail	0.9	0	0	0
Poor cod	3.1	0	0	0
Sand goby	0	4.5	6.7	0
Solenette	58.9	8.5	22.3	60.2
Sprat	3.4	0	41.1	2.1
Thornback ray	0	1	0	0
Two spot goby	1.6	0	0	0
Whiting	0	26.6	27.6	1.1

o) Intertidal Fish Surveys

19.4.130 Intertidal fish surveys (Refs. 19.45-48) to a design compatible with Environment Agency WFD transitional waters fish sampling protocols, were instigated over Bridgwater Bay in mid 2009 and continued until early 2011. Over the latter half of 2009, a total of 2,500 fish represented by 20 species were caught. Variations in species richness, relative species composition and total abundance has been observed on both a temporal and spatial basis, with the two sampling methods (fyke and seine nets) also demonstrating selectivity in the species and life stages captured.

19.4.131 Results from these surveys (**Table 19.15**) have indicated that the intertidal zone near Hinkley Point is a foraging and nursery area for a broad range of species, including several species and life stages (such as juvenile sea bass and mullet). In accord with the findings of Ref.19.243, these species and life stages would appear to selectively use the upper intertidal zone in favour of subtidal habitats.

Table 19.15: Species Caught during the Intertidal Fish Survey

Species	Fyke Nets	Seine Nets
Atlantic cod, *Gadus morhua*	✓	
Atlantic herring, *Clupea harengus*		✓
Common goby, *Pomatoschistus microps*	✓	✓
Common sole, *Solea solea*	✓	✓
Conger eel, *Conger conger*	✓	
Couche's goby, *Gobius couchi*		✓
European eel, *Anguilla anguilla*	✓	✓
Flounder, *Platichthys flesus*	✓	✓
Sand goby, *Pomatoschistus minutus*	✓	✓
Sea bass, *Dicentrarchus labrax*	✓	✓
Smooth hound, *Mustelus mustelus*	✓	
Sprat, *Spratus sprattus*	✓	✓
Pollack, *Pollachius virens*		✓
Poor cod, *Trisopterus minutus*	✓	
Thinlip mullet, *Liza ramada*	✓	✓
Transparent goby, *Aphia minuta*		✓
Whiting, *Merlangius merlangus*	✓	✓
5-Bearded rockling, *Ciliata mustela*	✓	✓
3-Spined stickleback, *Gasterosteus aculeatus*		✓
15-Spined stickleback, *Spinachia spinachia*		✓

p) Fish Impingement at Hinkley Point B in 2008 and 2009

19.4.132 Forty-two species of fish were recorded from the monthly impingement samples between January 2008 and June 2009. As is normal for the Bristol Channel, whiting and sprat were the most abundant fish species. A notable feature was the large number of snake pipefish impinged on the screens (this was the first time large numbers of this species have been recorded at HPB over a sampling period extending over the last 30 years). It is likely that many snake pipefish were able to penetrate the 1cm mesh and therefore passed through the cooling water circuit. This suggests that this pelagic pipefish has recently become extremely abundant in the estuary.

19.4.133 A comparison of the relative abundances of fish impinged upon the power station screens and those sampled offshore showed that sprat and whiting dominate the fish fauna at all sampled localities. Furthermore, of the 18 recorded species impinged on the screens in 2008, 13 were also caught in one or more of the offshore samples. A comparison of the fish species and relative abundances recorded offshore and from the power station screens, showed that herring, sprat and whiting dominated the fish fauna at all localities.

19.4.134 Sixteen species of fish were recorded from the monthly impingement samples in May and June 2009. As is normal for this locality at this time of year, the catch was dominated by whiting, with Dover sole and flounder also common (737, 217 and 90 individuals caught respectively). Late spring to early summer is the time of year when fish abundance and species richness is at the minimum for the year. A notable feature of the June 2009 sample was the unusually large number of juvenile 0+ cod impinged, an indication of what has probably been the second highest level of recruitment in that stock of cod in the historical time series. This was the largest number recorded in a six hour sample since sampling at HPB began in 1981. The long term time-series of sampling maintained at HPB has tended, over the years, to mirror the spikes in cod recruitment known from fisheries studies fairly well. Data fhe Comprehensive Impingement (CIMP) survey (Ref. 19.36), operated by BEEMS in parallel to that longer term effort over 2009/10, clearly show those juvenile cod being impinged in large numbers at that time.

19.4.135 Of the 32 species impinged during the survey period (November 2008 to October 2009), 21 were sampled offshore. In addition, four species were sampled offshore which were not recorded at the intake during this period (anchovy, pearlside, sand eel, and solenette).

q) Commercial Fishing

19.4.136 This section provides baseline information on commercial fisheries within the Severn Estuary and Inner Bristol Channel area (i.e. the area around Hinkley). Ref. 19.32 considers the fisheries resources present in the area and those that depend on it in the commercial fishing sector. The catching sector supports a range of associated upstream activities, such as vessel and gear suppliers, and downstream activities such as marketing, processing and distribution. Due to the estuarine nature of the area and importance of commercial fisheries for migratory species such as eels and salmonids, these are also discussed in this section.

19.4.137 Ref. 19.32 reviews a number of data sources including:

- Radiological habits survey (Ref. 19.149).
- Coastal Fisheries of England and Wales (Ref. 19.150).
- Landing statistics from the Marine and Fisheries Agency.
- Communications with Industry Liaison Officers, North Devon Fisherman's Association and South Wales Sea Fisheries Committee.
- Data from the Environment Agency.

i. Overview of Fishing Activity in the Bristol Channel and Severn Estuary

19.4.138 Commercial fishing effort in the Outer Bristol Channel is extensive with vessels from the North Devon, Cornish and South Wales coastlines targeting a variety of species throughout the year. Fisheries include potting for lobsters, crabs and whelks, with netting and trawling targeting the ray and mixed fisheries. Targeted fisheries for squid and sea bass also occur during the summer months with some North Devon boats fishing off the sand banks in the Bristol Channel.

19.4.139 There are also commercial fisheries for migratory species, including salmon, sea trout and eels in the Severn Estuary and surrounding rivers. However, the value of rod fisheries dwarfs those of netting, and is mainly concentrated in the River Wye, targeting salmon. An Environment Agency study (Ref. 19.151) estimated the market value of fishing rights for salmon rod fisheries in England and Wales to be £128 million. This was based on an average rod catch of 15,200 fish and an average value of £8,400 per salmon caught. In contrast, the same study concluded that in 2001 the net economic capital value of salmon net fisheries in England and Wales was around £3 million.

ii. Marine Fisheries

19.4.140 The level of commercial fishing activity in the Severn Estuary and Inner Bristol Channel (Ref. 19.32) is generally much lower than on grounds to the west, principally as a result of the strong tides, together with the low density of fish above the statutory Minimum Landing Size (MLS). The Estuary acts as important nursery grounds for many commercially valuable species, including sole and sea bass and, as a result, the majority of the fish found within the Estuary are juveniles.

19.4.141 During the surveys reported in Ref. 19.149, it was noted that the level of commercial fishing was relatively low, with five full-time commercial fishers active in the area, three at Stert Flats at Stolford using stake-nets and set-nets, two at Blue Anchor also using stakenets and a further two fishers that had commercial licences but were not using them, but based out of Watchet. Commercial fishing for crustaceans was only identified at Stolford. There, two fishers were setnetting over mud mainly for brown shrimps, *C. crangon*. To the east of Hinkley Point, two fishermen maintain ranks of fixed stowe or stake-nets on the Steart Flats, catching shrimps, mullet, rays and sole from July to October (Ref. 19.150), and molluscs are gathered by hand.

19.4.142 Many of the commercial fishing vessels operating out of the north Somerset and South Wales coastal areas are under 10m in length and operate on a part-time basis supplementing income with charter angling trips, especially for cod which have remained relatively abundant in the area. The under 10m fishing fleet is not required to submit logbooks to Defra detailing catch levels. However, under the Commission Regulations (EC) No 1077/2008, an audit trail is now established to track all landings from first point of sale, although no data are as yet available from this process.

19.4.143 There are three <10m vessels working part time from the Usk at Newport, using small beam trawls for flatfish and brown shrimps which are also taken in Cardiff Bay (Ref. 19.150). There are two part-time boats operating out of Minehead, setting pots and taking out angling parties with several part-time boats also setting pots and nets close inshore between Highbridge and Burnham-on-Sea. Two angling charter boats operate from Watchet Harbour, taking regular inshore angling trips along the coast between Blue Anchor and Stert Flats. It would appear from the available data that trawling and drift netting are no longer being practiced by anyone in the waters off Hinkley Point.

19.4.144 Marine Management Organisation (MMO, formerly the Maritime and Fisheries Agency, MFA) landings statistics cover the relevant ICES statistical rectangle (31E6), a summary of which is presented in **Table 19.16** (taken from Ref. 19.27).

19.4.145 **Table 19.16** shows the average landed weight (kg) per year for certain species and their value in pounds sterling. The species with the greatest value per kilogram is sole, followed by sea bass and then cod. When actual catches are looked at, sea bass is most valuable, followed by crab and then plaice. Overall, sea bass is considered the more commercially important species, followed by sole and crab. The catches and price of the other species make them profitable, but not the main area of focus. These data are well reflected in the types of gear used in the area, driftnets and fixed nets to catch sea bass and cod, pots to catch crabs and trawling for sole and plaice.

19.4.146 The data represent the landings for the whole of statistical rectangle 31E6, and they cover a large area, including some commercially active ports such as Swansea and Port Talbot. Therefore, the actual level of commercial fishing around Hinkley Point cannot be calculated accurately.

Table 19.16: Average Annual (between 2004 and 2008) Weights (kg) and Values (£) of Fish Landings by ICES Statistical Rectangle

ICES Rectangle 31E6	Sea Bass	Cod	Conger	Crab	Herring	Plaice	Sole	Sprat	Whiting
Weight (kg)	6,335	1,342	168	4,847		1,450	1,427		153
Value (£)	34,585	2,992	136	6,401		2,692	12,298		111
Value (£/kg)	5.74	1.93	0.75	1.51	0.59	1.38	7.75	0.41	0.60

Note: *Values are either the actual value at the time of sale or, where this was not available, an estimate based on average prices maintained locally by MMO.*

19.4.147 Consultation with the MMO and local fisheries officers has corroborated the view that commercial activity in the Hinkley Point area is very limited. There have been no industry observer trips out of Watchet or Minehead, because there is no large-scale fishing activity there, and the only port nearby with commercial-scale landings is Ilfracombe.

19.4.148 The North Devon Fishermen's Association (NDFA) stated that none of its members operated as far up the Channel as Hinkley Point and they have no large-scale commercial activity east of Lynmouth; there are no trawlers or potters from the NDFA that work that ground. It was also stated that, because of the extremely strong tidal currents around Hinkley Point and further up the Bristol Channel, there would be little if any commercial trawling or drift netting.

19.4.149 The South Wales Sea Fisheries Committee (SWSFC) said that boats do use a lot of the Channel but would not operate as far up as Hinkley Point on any large scale.

iii. Migratory Fisheries

19.4.150 Fisheries for migratory species are of significant economic value, particularly in rural areas. However, overall salmon and sea trout netting is declining, in response to the phasing out of mixed stock fisheries and falling demand for wild salmon. Eel and elver net fishing in recent years has fluctuated in response to market forces.

19.4.151 Migratory species that are targeted commercially in the Severn Estuary and surrounding rivers include salmon, sea trout and eels. Both allis and twaite shad are also present in the Severn Estuary and were formerly fished commercially before numbers declined and the fishery collapsed. In the middle of the 19th century the value of shad rivalled that of salmon and in the River Severn, shad made up about one third of all catches.

19.4.152 Many of the net fishing methods used to target migratory species on the Severn Estuary are unique to the area and have a long history, notably lave netting (using a 'Y' shaped net and 'stalking' or 'cowering' in the shallows to catch the salmon migrating), and putcher nets (rows of baskets which use the ebb tide to trap salmon).

iv. Salmon and Sea Trout

19.4.153 The Estuary fisheries exploit mixed stocks of salmon originating from at least seven rivers entering the Estuary, most notably the Severn, Wye and Usk. Net licences issued for catching salmon also allow the fishermen to take sea trout. Hence, it is impossible to distinguish the allocation of effort between salmon and sea trout fishing. Sea trout are found in 26% of all rivers, and their distribution across England and Wales is very irregular. Wales has the widest distribution, with sea trout present in 49% of rivers. The licensed fishery in the Severn Estuary in 2007 comprised two seine nets, 20 lave nets and four fixed engines (e.g. putchers); see **Table 19.17**.

Table 19.17: Allowable and Utilised Effort for the Principal Salmon Net Fisheries in 2007

River/Fishery	Method	No. of Licences	Allowable Effort Net Days	% days Utilised	Av. Day/lic.
Severn	Putchers	4	304	79	60
Severn	Seine	2	312	0	0
Severn	Lave	20	1,560	15	12
Wye	Lave	7	553	24	19

Note: *adapted from Salmonid Stocks and Fisheries in England and Wales, 2007 (after Ref. 19.154).*

19.4.154 Salmon caught before 1st June must be released, with catches continuing from then until August. In 2000, local interests bought out drift netting in the mouth of the Usk, in Newport Bay and the putcher rank just upstream of Uskmouth which accounts for the lack of reported salmon net catches in the Usk after 1999 (**Table 19.8**). The breakdown of the net catches in the rivers Severn, Wye and Usk by gear type from 1999 to 2006 indicates that fixed engines or putchers account for the highest numbers of salmon taken. There are salmon putchers at the south-west and north-east ends of the Severn Bridge, at Aust and Beachley, and at Alvington below Lydney Lock (Ref. 19.154).

19.4.155 The total provisional figures for net and rod catches taken for the Midlands (River Severn) and Welsh (all rivers) regions in 2007 are described in Ref. 19.152 (see **Table 19.19**). The catches from these regions made up 21% of the total catches for England and Wales in 2007. Catch figures indicate the importance of the recreational rod and line fishery in Welsh rivers (especially the rivers Wye and Usk) with reported catches seven times higher than those of the net fishery. These figures do not take account of catches of salmon which go unreported (including those taken illegally), and it is estimated that there may have been a total of 22,000 additional fish caught in 2007 (Ref. 19.153).

Table 19.18: Summary of Salmon Net Catches Numbers Landed, 1999-2006

River	Method	1999	2000	2001	2002	2003	2004	2005	2006
Severn	Seine nets	35	41	5	20	38	43	25	13
	Lave nets	190	228	186	116	295	380	135	138
	Fixed engines	764	704	836	1054	1207	346	778	713
Wye	Lave nets	3	11	2	6	6	8	7	6
Usk	Drift nets	726	0	0	0	0	0	0	0

Note: *adapted from Salmonid and Freshwater Fisheries Statistics for England and Wales, 2006 (after Ref. 19.154).*

Table 19.19: Provisional Net and Rod Salmon Catches (including released fish) by Region for the 2007 Season

Region	Net Catch		Rod Catch		Total Catch	
	No.	Weight (kg)	No.	Weight (kg)	No.	Weight (kg)
Midlands	676	3,184	261	1,112	937	4,296
Welsh	613	2,022	4,488	16,239	5,101	18,261
Total	1,289	5,206	4,749	17,351	6,038	22,557

Note: *adapted from Salmon Stocks and Fisheries in England and Wales, 2007 (Ref. 19.153).*

v. Eels

19.4.156 Eels are found in all European countries bordering or connected to the North Atlantic. They are caught as elvers (juveniles returning from the sea) or adults in a variety of fisheries each with different levels of exploitation. Over the past two decades, catch data from across Europe show glass eel populations declining rapidly from the high levels of the 1970s, while 2001 produced a record minimum of just one percent of previous peak levels, and most recent data show a continued decrease and no significant recovery from the 2001 all time low.

19.4.157 Only hand-held dip nets are permitted for the capture of glass eels or elvers, and fishing is concentrated where the fish are plentiful and easy to catch, principally in estuaries of the Severn and other rivers draining into the Bristol Channel, such as the Parrett. Catch returns from these fisheries have been compulsory over the past few years and provide a good indication of the trend in eel recruitment. The fishing season is short, coinciding with the elvers entering rivers on spring tides in April and May (Ref. 19.154).

19.4.158 The number of licenses issued to fish for glass eel/elver in the Severn Estuary and Bristol Channel ranged from 487 to 577 between 2002 and 2004. Elvers are known to be targeted during their landward migration between November and March using dipnets within the area just seaward of Bridgwater Bay. The national 2007 catch was 2,051kg of which the Severn Estuary and Bristol Channel are estimated to represent 95% equating to a catch of 1,948kg. Based on an average individual weight per elver of approximately 0.5 g this would equate to 3,896,000 individuals. Only a small proportion of elvers caught are for domestic consumption, the majority are sold for re-seeding eel farms in Asia.

19.4.159 Eels are caught commercially in a number of locations and by a variety of instruments including fyke nets, putcheons and weir traps. The level of eel fishing effort is measured as the number of licensed instruments of all types. Licence sales in England and Wales have fluctuated between 1,500 and 2,700 (per year,) most likely in response to market price fluctuations. Many rivers throughout the Severn Estuary catchment support eel fyke net fisheries between spring and autumn. Fyke nets fished on the Wye take yellow eels in spring and summer and silver eels in autumn.

19.4.160 Between 2002 and 2004 the number of licenses issued for this fishery reduced from 80 to 47 although catches in fact rose over this period from 156kg in 2002 to 980kg in 2003 followed by a slight decline in 2004 to 569kg. The 2007 annual adult eel catch for Wales, South-West England and the Midlands was 2,396kg (data provided by the Environment Agency). The 2004 catch indicates that the Severn Estuary represents approximately 12% of this regional catch. As such, the 2007 adult eel catch for the Severn Estuary is estimated at approximately 288kg. Based on empirical data, there is presumed to be a 20:1 ratio of male to female eel in the Severn Estuary. Male and female eel reach maturity and migrate at different ages and, as such, will vary in weight. Taking an average weight of 90 g however for male silver eel of 90g and 580g for females (based on the most common ages at maturity), the adult eel catch for the Severn Estuary and Bristol Channel would equate to 3,040 males and 24.8 females.

vi. Recreational Fishing

19.4.161 Recreational angling accounts for the highest amount of fishing effort within the Severn Estuary and Inner Bristol Channel. Anglers fish from the shores along much of the Inner Bristol Channel targeting cod in the winter and sea bass in the summer, with other species such as whiting, flounder, eels, rays, sole and conger also caught. Angling is also carried out from charter vessels, and both forms represent an important recreational use of the Estuary, even though the quantities and values of fish taken are small compared to commercial fisheries.

r) Marine Mammals

19.4.162 A desk-based review of available data on marine mammals within the Severn Estuary and Bristol Channel was conducted. Subsequently, following the publication of guidance from by the Joint Nature Conservation Committee (JNCC) (Ref. 19.155), a network of acoustic sensors was deployed off the site.

19.4.163 A study of the Welsh shore of the Bristol Channel (around the Gower Peninsula and Swansea Bay) during the early 2000s documented regular occurrences of the harbour porpoise (*Phocoena phocoena)*, as well as occasional sightings of the common dolphin (*Delphinus delphis)* (Ref. 19.156).

19.4.164 Aside from this study, there is little available information regarding cetacean activity in the areas of the Inner Bristol Channel and Severn Estuary, although common dolphin *(D. delphis)*, bottlenose *(Tursiops truncatus)* and Risso's *(Grampus griseus)* dolphins, as well as grey seals *(Halichoerus grypus)* have been recorded in the wider Bristol Channel area in the past (Ref. 19.157).

19.4.165 The BEEMS programme has initiated an acoustic monitoring programme to assess cetacean site usage in relation to potential HPC construction impacts (Ref. 19.57). Recording devices have been deployed at two locations around the proposed temporary jetty and the cooling water intake and outfall structures, and a further three locations on a depth transect from the front of the station around 25km westwards into the Bristol Channel (**Figure 19.15**). These record cetacean 'clicks', the vocalisations used as a means of navigation and prey location (Ref. 19.156). The devices have been *in situ* for approximately since early 2011.

19.4.166 Harbour porpoise have been recorded at each of the five locations, including the vicinity of the proposed jetty and intake/outfall structures; see **Figure 19.15**. The initial dataset suggests a strong depth-preference, with the number of days on which porpoise were recorded increasing along the gradient from the existing station towards the open waters of the Channel (**Table 19.20**). The data on dolphin clicks have yet to be analysed, so the occurrence of these species in the area remains unclear, but initial inspection of the data suggests they are also found in the area.

Table 19.20: The Number of Days of Porpoise Recordings at the BEEMS Acoustic Recording Stations around Hinkley Point (from Ref. 19.57) during Initial Survey Period of 77 Days

Station	Location	Approximate water depth (m)	No. of days when porpoise clicks were recorded	Percentage of total recording days when porpoise clicks were recorded
1	Vicinity of proposed jetty	3.4	7	9
2	Vicinity of proposed intake/outfall	5	10	13
3	Inner transect, north-west of station	12	30	39
4	Mid-transect	12	20	37
5	Outer transect	20	51	66

19.4.167 Information on site fidelity and temporal patterns in the Channel's cetaceans is scarcer than that on their occurrence. It is unclear if the harbour porpoise recorded in the area are local residents or visitors, though workers involved in the Welsh study suggest they may be resident (Ref. 19.156). There is no clear evidence of significant seasonal patterns in the Welsh porpoises, although there is some indication of seasonal aggregations in the Carmarthen area (during November; see Ref. 19.156).

19.5 Scope of Assessment

a) Existing Baseline Condition

19.5.1 Section 19.4 above describes the existing baseline condition, in terms of the observed character of the local marine ecological interests, against which the assessment developed within this chapter is then undertaken. That baseline incorporates the presence and function of the existing HPB station. Where the impacts of HPB operations are isolated in the assessment below this is solely for the purposes of supporting, as a surrogate, understandings and predictions of the likely impacts of HPC beyond that baseline condition.

19.5.2 In recent years the HPB station has been obliged to maintain a lower operational load, meaning that reduced volumes have been abstracted and a reduced thermal output has been put to sea. These reduced volumes have been taken into account in characterising the impingement rates observed at that station and elaborated upon in predicting catches for HPC. Likewise, the development of numerical hydrodynamic models in support of the HPC development over this period has been calibrated against the reduced plume signature.

19.5.3 For the purposes of this assessment, calculations of the baseline condition have presumed the HPB station to be operating at 100% load, this being what is permitted under that station's consent to operate. So, for example, all plume extents are mapped with HPB operating at full load and the starting point for any comparison with fishing mortality will include, as baseline, the predicted influence of that existing operation, again at full load.

19.5.4 The observed condition of the benthic fauna utilised in this assessment will have been representative of HPB at high load, given that load reductions began just before the surveys commenced.

b) Significant Elements of the HPC development

19.5.5 The elements of the proposed HPC power station development which could lead to potential effects on the marine environment are likely to be the construction and operation of the following:

- the temporary jetty;
- the seawall;
- land-based discharges; and
- the cooling water system.

19.5.6 For each of these a number of potential impacts have been identified. Generally, these impacts can be grouped into several broader categories (e.g. habitat loss and disturbance). The proposed Fish Recovery and Return system is considered in Section 19.8, Mitigation.

c) Temporary Jetty

19.5.7 A temporary jetty would be constructed and operated during the overall construction phase for the HPC project. As a temporary structure, the potential effects of jetty construction, operation and dismantling are considered as a part of the construction stage of the project. These activities have the potential to generate the following changes which could impact on marine habitats and species:

- intertidal and subtidal habitat loss and disturbance due to piling, construction and maintenance activities;
- physical disturbance to habitats due to alterations in longshore current patterns caused by both the jetty structures themselves and dredging (including maintenance dredging) of the berthing pocket;
- alterations in water quality due to run-off from the jetty and its constituent materials during construction and dismantling;
- noise and vibration due to piling and vessel movements; and
- artificial lighting during construction and operation.

d) Construction of the Seawall

19.5.8 A new seawall will be constructed for coastal protection purposes on the line of the existing cliffs fronting the HPC Development Site, at the top of the intertidal shore. These activities have the potential to generate the following changes which could have an impact on marine habitats and species:

- loss of upper shore habitat and modification to slope of intertidal zone;
- physical disturbance to the upper shore during construction (machinery access and trampling by people);
- water quality alterations on the shore via run-off from works and other potential contaminant release;
- noise and vibration caused by operation of machinery and rock removal; and
- artificial lighting during 24 hour construction of the seawall.

e) Land Based Discharges

19.5.9 Construction and operational activities on the main site have the potential to create discharges, which could generate changes in water quality that have an impact on marine habitats and species.

f) Cooling Water System

i. Construction of the Vertical Shafts Offshore

19.5.10 The construction of the cooling water system, involving the construction of vertical shafts approximately 1.8km offshore for the placement of outfall structures and 3.3km offshore for intake structures, has the potential to generate the following changes which could impact on marine habitats and species:

- temporary and permanent loss of seabed habitat;
- physical disturbance to the seabed around each drilling site;
- water quality alterations due to discharges from dewatering activities and from platforms and support vessels, waste materials, chemicals associated with drilling operations;
- water quality alterations due to sediment disturbance and potential contaminant mobilisation;
- noise and vibration associated with both pile driving (for anchorage of platforms) and vessel movements; and
- artificial lighting if offshore construction works continue during the hours of darkness.

ii. Construction of the Horizontal Tunnels

19.5.11 The main cooling water tunnels connecting the power station itself to the cooling water intakes, via the shafts described above, will be drilled beneath the intertidal shore and seabed from land. All waste arisings will thus be managed, at least initially, onshore. These activities have the potential to generate the following changes which could impact on marine habitats and species:

- water quality changes due to discharge of waste water from tunnel drilling. If mud-assisted drilling is used this could contain suspended solids (including bentonite), organic polymer, and waste salts following control of pH; and
- vibration and noise.

iii. Operation of the cooling water systems

19.5.12 The operation of the cooling water systems at HPC will involve the abstraction and subsequent discharge of approximately 125 $m^3.s^{-1}$ on a virtually continuous basis over the full generating lifetime of that station. The principle impacts of abstraction will be: the impingement of fish and other marine life on screens; the entrainment of smaller organisms through these screens, their passage through the plant, subjection to stresses of pressure, increased temperature and potential chlorination and their subsequent return to sea; and any influence caused by the thermal plume arising and any associated residual biocides associated with the discharge.

19.5.13 Although the decision was made from the outset to incorporate relevant best practice mitigation into the design of the HPC cooling water system, no allowance for these features has been made in completing the initial assessments that follow below. Best practice measures include: the offshore location of intakes; use of low velocity side entry (LVSE) intake design; use of a behavioural cue at these intakes to deter fish; and use of a means of fish recovery from the screens in order to return fish and crustacean to sea in good condition.

19.5.14 This approach has permitted a direct translation of observed (and unmitigated) impingement levels at HPB across to predictions at HPC. The benefits of applying best practice in terms of mitigation are then considered in Section 19.8 of this chapter.

g) Accidents and Incidents

19.5.15 There is the risk of impact due to accidents occurring during construction (e.g. water quality changes due to chemical spillages and surface water discharges containing spilled/leaked contaminants) and, to a lesser degree, during operation. It is not possible to assess the potential impact of such incidents/accidents as they could vary significantly in scale, location and type with variable outcomes on potential receptors.

19.5.16 The implementation of best practice management measures during construction and operation will be the mechanism by which the potential risk of accidents occurring is managed and any consequential impacts are either eliminated or minimised.

19.6 Assessment of Impacts

a) Introduction

19.6.1 As a result of the very high suspended sediment concentration of the Inner Bristol Channel, the marine waters and the physical habitats and assemblages associated with them have a particularly low sensitivity to localised disturbances to the sediment regime. Similarly, as described in **Volume 2 Chapter 17**, the extremely dynamic nature of the Inner Bristol Channel (i.e. an extreme hyper-tidal range, associated with high current speeds), its physical scale and the level of temporal and spatial variance that are already the norm, due primarily to the tidal regime, strongly suggest that in order for any significant change to occur a human intervention in the system would, itself, have to be very significant. Within this context, the main marine infrastructure components considered as a part of this development are, in comparison, either of a very small scale (e.g. the intake-outfall structures) or designed so as to offer little hindrance to coastal processes (e.g. the temporary jetty). There are clear exceptions however, most obviously the issue of *Corallina* turf habitat discussed below.

19.6.2 With specific reference to the operational phase, whilst the scale of cooling water abstraction and discharge may appear from an anthropocentric perspective to be large, the physical scale and the level of temporal and spatial variance described above mean that the actual influence of these activities tends to be subtle and, even with considerable effort, difficult to discern. This is certainly the case for the thermal plume that will be associated with HPC. The plume will be characterised by localised increases in sea temperature and residual traces of contaminants, both of which will diminish with time and distance from the outfall and depth through the water column. The dynamic behaviour of this plume will be dictated by a combination of the effluent's low relative density and the ebb and flood tidal currents. The result is a relatively widespread but nonetheless subtle area of influence.

19.6.3 These physical processes not only lend themselves to numerical modelling but also, given the thermal signature of any existing plume's presence and the appropriate level of care, provide a means of calibration and validation of these models which then in turn permits a high level of confidence in their predictions. These predictions can extend to the outer reaches of that plume's influence. An ensemble of such predictive tools have been employed extensively in support of the assessment that follows within this chapter. The development of the models used in support of the HPC assessment is described within **Volume 2 Appendix 18A** of this ES.

19.6.4 Just as these issues of scale and variance are highly significant for any consideration of HPC within the context of the physical environment of the waters off Hinkley Point, any consideration of the ecology of these same waters is subject to the same conditions in terms of the biological response to these same conditions. In the simplest terms, the ecology is driven by and responsive to the scale and variance of the physical environment it inhabits. One of the consequences of that environment around Hinkley is that many of the species involved are highly resilient to variations in salinity, temperature and high levels of suspended solids. Many are also, through either reproductive or dispersal strategies, their migratory behaviours (both seasonal and tidal), and their form and habit, resilient to the degree of physical disturbance and tidal displacement which represent, in this hypertidal environment, the norm.

19.6.5 Whilst these attributes of the local marine and estuarine ecology are significant in considering the effects of construction-related disturbance and the potential impacts of the thermal plume, density dependence can also be significant when considering the potential impacts of impingement and entrainment. The general principle of density dependence is that increasing population size reduces available resources, limiting population growth. So when numbers of young fish are caught by either fishing activities or a power station this same principle suggests that survival and growth amongst the remainder of the population involved will increase. Due to the high level of complexity involved, density dependant factors such as this cannot be taken into account in the assessments completed below but, where this applies, it lends an additional level of precaution to the estimates used.

19.6.6 Having stated that elements of the physical environment are open to high levels of predictability, there are also significant elements of uncertainty fundamental to the assessments that follow. Populations of individual species will rise and fall within years and between years in a complex manner. This is most obviously the case for species that are well studied, such as commercial fishery stocks, but it will also be true for those not subject to this level of scrutiny. The baseline characterisation studies described above, and the population or stock size estimates utilised in the assessment that follows, provide reasonable understandings of the present day condition and are considered to be sufficient to need in this instance, but they are also subject to constant change. In sum, however, the functional components of that ecology will tend to track the physical regime, so although specific components of that ecology (such as an individual species population) will tend to increase and decrease in a complex fashion, the functionality and attributes of the assemblage as a whole will tend to behave more conservatively. This means that assessments made today, on the basis of good knowledge should, with care and maintenance of that assessment, remain relevant over time.

b) High value receptors

19.6.7 A number of receptors considered in this assessment are recognised as being of high value in conservation terms. For the purposes of predictions of impacts, however, the technical assessment has been developed on the basis of their sensitivity to the specific pressure or 'stressor' under consideration. Examples of where this approach has been used include the reef-building polychaete worm *Sabellaria alveolata* and the algal turf forming species *Corallina*. Despite this approach, the value of the receptor has nevertheless not been ignored in final determinations.

c) Potential Impacts during Construction

i. Habitat Loss and Change

19.6.8 A number of components of the construction works and activities will lead to small-scale habitat loss and/or change in existing habitat conditions. This section covers those activities that will lead to permanent loss of marine habitat (intertidal and subtidal) and/or permanent change. Temporary disturbance to habitat during construction is covered under the section on physical disturbance.

19.6.9 The location of the proposed temporary jetty in relation to the intertidal area is shown in **Figure 19.16**. The installation of piers to support the jetty would result in direct habitat loss in the intertidal area. Some 52 piers would be installed across the intertidal area and the footprint of these piers would cover an area of approximately 34m^2. These piers across the intertidal area would be installed by using a balance of land-based plant gaining access across the shore, and marine engineering plant, such as a jack-up barge or rig, working from seaward.

IMPACT: Intertidal Habitat Loss as a Result of Construction of the Temporary Jetty

19.6.10 The Hinkley intertidal area supports communities that, in terms of species composition, may be considered typical of such coastlines around much of the UK. The fucoids *Fucus spiralis* and *Fucus vesiculosus* in particular are typical of sheltered to moderately exposed shores and occupy much of the intertidal at Hinkley Point. These species are widespread in their distribution and are not species of conservation concern. With the exception of the *Corallina* habitat, this intertidal area is thus considered to be of medium value.

19.6.11 The *Corallina* swards are of significance as they have been identified as a notable community of the hard substrate habitat which is a sub-feature of the SAC.

19.6.12 There are no areas of intertidal or subtidal *Sabellaria* reef in close proximity to the proposed jetty location; this was confirmed both by an acoustic seabed survey and subsequent ground-truthing carried out to check this understanding locally (Ref. 19.35). The nearest area of *Sabellaria* reef is a small section within the intertidal >500m to the east (in front of HPA) and a wider area some 500m to the west. As no *Sabellaria* reef habitat is located close to the jetty no impact is anticipated for this receptor.

19.6.13 Thus whilst it is clear that some small-scale habitat loss would occur, the footprint of the jetty piles is negligible in relation to the area of the intertidal zone (**Figure 19.16**) and the magnitude of the effect on that intertidal area as a whole is, therefore, considered to be low. In addition the majority of the habitats represented within the intertidal area are common and the species involved are widely dispersed across the Hinkley Point intertidal and throughout the UK, suggesting medium value. Taking these factors into account, the impact of this small-scale loss is considered **minor adverse** with regard to the majority of the intertidal communities present. The presence of *Corallina* turf in the area, however, merits further consideration.

IMPACT: Loss of Corallina as a Result of Construction of the Temporary Jetty

19.6.14 The *Corallina* biotope is considered to be of high value. The locations of channels with *Corallina* and associated run-offs were mapped and are shown in relation to the proposed jetty in **Figure 19.17**. It can be seen that the jetty will be located in the vicinity of the western extent of the channels supporting *Corallina* but has been deliberately positioned between, rather than over, mapped areas of cross-channel features that are heavily colonised by this species (and can be described as maintaining *Corallina* turf).

19.6.15 Given the proposed siting of the temporary jetty, the scale of this habitat loss would be very small and it is likely that *Corallina* would only be present in parts of the habitat lost. In addition, recolonisation will occur after the removal of the jetty. Hence, the magnitude of this effect is predicted to be very low and the significance of the impact is assessed to be **minor adverse**.

IMPACT: Intertidal Habitat Change as a Result of Construction of the Seawall

19.6.16 The upper area of the shore where the seawall would be constructed is effectively unoccupied by marine species and dominated by cobble/shingle material associated with both washout from the cliff and storm-driven longshore transport. The biotope is classified as 'barren littoral shingle', as shown by **Figures 19.8-10**. Within the construction area itself, **no impact** upon marine fauna or flora would thus occur.

IMPACT: Subtidal Habitat Loss as a Result of the Construction of the Vertical Shafts for the Cooling Water System

19.6.17 Habitat loss would occur due to excavation of the seabed for the construction of vertical shafts connecting to the horizontal (intake and outfall) tunnels. Habitat loss/modification would be permanent for the area of the estuary bed required for the vertical shaft openings. It would be temporary at the anchoring locations (wet drill operation) and for the area around the vertical shaft opening.

19.6.18 The benthos of the area surrounding both the intake and outfall structures is typical of the extensive muddy plain that makes up most of the local seabed. Population densities are low due to the extreme tidal conditions. The most prevalent species around the proposed vertical shaft sites are the oligochaete *Tubificoides amplivasatus* and the polychaete *Nephtys*. All species identified are commonly found at a national level. The biotope concerned is '*Nephtys hombergii* and *Macoma balthica* in infralittoral sandy mud', also described as 'Mobile circalittoral sandy mud supporting a sparse faunal compliment', a biotope which covers approximately 76km^2 out of the total of 94km^2 surveyed locally – see **Figure 19.18** (Refs. 19.14 and 19.25). The habitat type which is likely to be lost is thus locally common and widespread as well as being common throughout estuaries in the UK.

19.6.19 The vertical intake shafts in total would represent a loss of subtidal habitat of approximately 58m^2. The area of the opening of the outfall vertical shafts would be approximately 39m^2. This represents significantly less than 0.1% of the area of the '*Nephtys hombergii* and *Macoma balthica* in infralittoral sandy mud' within Bridgwater Bay. In addition, during wet drilling, there would be temporary loss of habitat around the anchor sites, which would again probably be in the region of 0.1% of the area of the dominant biotope in Bridgwater Bay. The percentage of this habitat lost due to construction of the vertical shafts in relation to its local extent is considered to be small and, therefore, the magnitude of this effect is assessed as very low. The sensitivity of the receptor to impact is low and, thus, the significance of the impact is predicted to be **negligible**.

IMPACT: Indirect Impact to Subtidal Fauna as a Result of the Construction of the Vertical Shafts for the Cooling Water System

19.6.20 The predominant epifauna within the area is the brown shrimp *Crangon crangon*. As with other mobile epifaunal species, *C. Crangon* would be able to move away from the area to seek suitable nearby habitat and would be less affected by the habitat loss. In the areas of disturbance around the shafts a typical faunal assemblage would very quickly become re-established due to tidal mobilisation of surface sediments. Even in less dynamic systems the evidence from studies of recovery rates in subtidal benthic communities of the type present within the footprint of the works clearly demonstrates that soft-sediment, bivalve-annelid dominated communities are able to recover from disturbance events within one to two years (Ref. 19.161). As a result, the sensitivity of this habitat is considered to be low.

19.6.21 Overall, given that rapid recovery of affected areas within the construction footprint would be expected, the impact of this activity would be predominantly related to the small-scale habitat loss (as described above). The loss of this area of habitat would have a **negligible** impact upon the extent and functioning of the affected subtidal communities.

19.6.22 The small loss of subtidal habitat that would occur during construction of the shafts would not be expected to have any impact on prey availability for fish.

IMPACT: Sabellaria as a Result of the Construction of the Vertical Shafts for the Cooling Water System

19.6.23 Subtidal *Sabellaria* may be present at the vertical shaft sites, however, given the local habitat type involved, it is not anticipated that any reef formations would be present. Therefore, it is considered that there would be **no impact** on *Sabellaria* reef through construction of the vertical shafts.

IMPACT: Subtidal Habitat Change due to Capital and Maintenance Dredging

19.6.24 As noted in **Volume 2**, **Chapter 17**, the operating face of the jetty head will be aligned with the direction of ebb/flood tidal currents in the vicinity. A berthing pocket immediately associated with that operational area will be dredged in order to allow safe delivery of materials across a range of tidal conditions. This dredged area is estimated to be 160m in length and 27m in width with sediments removed to a uniform depth of around 3.5m below the existing seabed (4.5m below Chart Datum (CD)).

19.6.25 Given the uniform nature of the substrate with depth (Ref. 19.26) and the dominance of the tidal regime and the associated processes of sediment suspension, mobilisation and deposition, any physical habitat loss due to dredging within this chronically disturbed environment is expected to be of short duration, and given the dominant sedient transport regime a typical subtidal assemblage is likely to become re-established quickly thereafter.

19.6.26 Again, the benthos of this area is typical of the extensive muddy plain that makes up most of the local seabed. Population densities are low due to the extreme tidal conditions. All species identified are commonly found at a national level. The biotope concerned is *'Nephtys hombergii* and *Macoma balthica* in infralittoral sandy mud', also described as 'mobile circalittoral sandy mud supporting a sparse faunal compliment', a biotope which covers approximately 76km^2 out of the total of 94km^2 surveyed locally – see **Figure 19.18** (Refs. 19.14 and 19.25). The habitat type which is likely to be affected in this instance is thus locally common and widespread. Hence the magnitude of the effect is predicted to be low.

19.6.27 As with the area around the cooling water headworks, the predominant epifauna within the area is the brown shrimp *C. crangon*. As with other mobile epifaunal species, *C. crangon* would be able to move away from the area to seek suitable nearby habitat if need be. In the areas of disturbance both within the berthing pocket area itself and around its margins, a typical faunal assemblage would very quickly become re-established due to tidal mobilisation of surface sediments. Even in less dynamic systems the evidence from studies of recovery rates in subtidal benthic communities of the type present within the footprint of the works clearly demonstrates that soft-sediment, bivalve-annelid dominated communities are able to recover from disturbance events within one to two years (Ref. 19.161). As a result the sensitivity of this habitat is considered to be low.

19.6.28 On this basis, the significance of the impact has been assessed as **minor adverse**.

ii. Physical Disturbance

IMPACT: Disturbance to Intertidal Habitats during Construction of the Temporary Jetty

19.6.29 Several activities associated with the construction of the jetty may cause disturbance to the intertidal area within and adjacent to its footprint, including piling, dredging and the use of construction plant and materials. The impacts of dredging are discussed in Paragraph 19.6.42 below. Piling works (the drilling/piling and use of jack-up rigs) has the greatest potential to cause disturbance, along with the machinery movements required to emplace the jetty infrastructure. These activities may lead to the generation of debris (e.g. from drilling), channel blocking, smothering and the abrasion of rock surfaces supporting intertidal communities.

19.6.30 Plant and vehicles working on the intertidal shore itself will be deliberately constrained within narrow construction corridors no more than 20m wide to either flank of the jetty structure itself, and a similarly constrained 10m wide route along the top of the intertidal area (above MHWS) in order to provide landward access to the works. A wider corridor (75m to either flank of the line of the jetty) will limit the deployment of marine engineering plant, such as a piling barge.

19.6.31 The volumes of fine sediment generated during drilling and through disturbance by machinery on intertidal sediments are likely to be very low in comparison to the existing high sediment loadings present in the water column. The sensitivity of local habitats is considered to be medium, and the significance of this impact is therefore predicted to be **minor adverse**.

IMPACT: Disturbance to Sabellaria due to Construction of the Temporary Jetty

19.6.32 There is no observed occurrence of intertidal or subtidal habitat supporting *Sabellaria* reef within 500m of the jetty and therefore the likelihood of this receptor being directly impacted by the jetty construction works is considered highly unlikely. Although there is the potential for some sediment disturbed during construction to be transported into intertidal areas supporting *Sabellaria* reef, it is considered that the overall volumes would be negligible in the context of the high volumes of sediment routinely present in the water column. As such, **no impact** on *Sabellaria* reef is predicted in terms of this aspect of the temporary jetty construction works.

IMPACT: Disturbance to Corallina due to Pile Driving and Plant Movements

19.6.33 Disturbance to intertidal habitat in the vicinity of the jetty would be unlikely to affect the continuing presence of many of the intertidal species present (e.g. fucoid dominated communities). Given the species involved, the recolonisation of any disturbed areas would be expected to be relatively rapid (one to two years). No long-term effects would thus be expected.

19.6.34 However, as stated previously, *Corallina* turf is considered to be of importance as it provides a habitat for many other organisms; it is also, for this reason, recognised as a notable community of the hard substrate habitat which is a sub-feature of the SAC. It is, therefore, considered to be of high value. On the basis of the mapping work, the *Corallina* biotope intermittently occurs within an area of some 500m x 50m.

19.6.35 An additional factor is that the longshore drainage channels upon which the *Corallina* run-offs themselves depend tend to flow from east to west across the shore, implying that any disturbance to one of these channels may have an impact on habitat areas to the immediate west of the construction area. The jetty will be located towards the western end of the extent of the known distribution of *Corallina* (see **Figure 19.17**) and the alignment deliberately avoids the mapped *Corallina* spillways. Even if the construction area activities were to extend further than 20m from the actual alignment of the jetty itself, this suggests that in total an area of less than 4% of *Corallina* biotope area (*c*. 118,800m^2 within the vicinity of Hinkley Point) would be present within the footprint of the works, although this area would increase if a longshore drainage channel were to be compromised. This would nonetheless represent a relatively small area and indicates that even if all of the *Corallina* biotope within this wider area were disturbed, which would be highly unlikely, this change would be of very low magnitude, resulting in a **minor adverse** impact.

IMPACT: Intertidal Habitats due to Scour Associated with Jetty Piers

19.6.36 An expert assessment of the level of sediment scour (see **Volume 2, Chapter 17** for further information) that would be associated with the jetty piles due to waves and tidal streams has shown that soft sediments would be scoured to a depth of no more than 1.3m in the immediate vicinity of the piers themselves.

19.6.37 The top width of a scour hole in non-cohesive sediments is a function of the scour depth and the angle of repose of the sediment involved. As a conservative measure, the angle of repose associated with a loose fine sand would be in the order of 26-28°

which translates into an area around each pier foot, in soft sediment, of no more than a couple of metres.

19.6.38 This impact on sediment distribution would be limited to the length of the jetty that extends across the muddy seabed. The extent of this disturbance feature around the piers themselves is predicted to be very low and would be confined to a habitat type (i.e. soft sediment) that is subject to continual remobilisation due to tidal forces, and thus of very low sensitivity. The sediment transport processes associated with scour are normal to this hypertidal (>6m tidal range) habitat and the impact associated with this element of disturbance is, thus, assessed as **negligible**.

19.6.39 The effect described above would not occur in association with the piers introduced across the exposed rocky platform of the intertidal shore or the exposed rock that the line of the jetty will cross in the near subtidal area. Shear forces around the foot of these structures will be increased and could result in a loss of fauna and flora in the immediate area around each. Again, the extent of this disturbance feature around the piles themselves is predicted to be very limited and any loss of associated flora and fauna of very low magnitude. The impact associated with this element of disturbance is thus assessed as **negligible**.

19.6.40 **Volume 2**, **Chapter 17** discusses the potential impact of construction works on the superficial geology of the cross-shore rock platform flanking the jetty, and recognises that a moderate adverse impact may occur due to the high sensitivity of the receptor but relatively low magnitude of the effect involved.

IMPACT: Intertidal Disturbance Associated with Construction of the Seawall

19.6.41 Under the existing coastline configuration, the alignment of the proposed seawall places it above the Mean High Water Mark.

19.6.42 The construction works would require that machinery for the excavation works and actual placement of the seawall have access to the upper intertidal area, either on a permanent or temporary basis depending on whether tidal conditions permit. Given that rock from the upper intertidal area would be removed during excavation (this impact is covered under the section on habitat loss/change, see above), further disturbance would therefore be limited to any additional effect that machinery operating along the upper shore would have on existing intertidal communities.

19.6.43 There is also the potential for some sediment release during the excavation and construction of the seawall. The volume of sediment released is anticipated to be minimal and is unlikely to result in any noticeable increase in sedimentation on the intertidal area either in isolation or in combination with other construction activities.

19.6.44 A 30m wide construction zone will be established fronting the HPC Development Site and all works on the sea wall confined to this zone. **Figure 19.35** shows the extent of that zone in relation to intertidal habitat distribution (Ref. 19.55). The biotopes that would be involved within the footprint of this zone are (areas rounded to nearest 10 m^2 and indications of recoverability from MarLIN database: http://www.marlin.ac.uk/):

- Eunis A1.32; 1,200 m^2; 'Fucoids on variable salinity rock'; high recoverability (full recovery within about 5 years).
- Eunis A1.321; 4,530 m^2; '[*Pelvetia canaliculata*] on sheltered variable salinity littoral fringe rock'; moderate recoverability (full recovery up to 10 years).
- Eunis A1.322: 1,710 m^2; '[*Fucus spiralis*] on sheltered variable salinity upper eulittoral rock'; high recoverability (full recovery within about five years).
- Eunis A1.421: 430 m^2; 'Green seaweeds [*Enteromorpha spp.*] and [*Cladophora spp.*] in shallow upper shore rockpools'; very high recoverability (full recovery within at most 6 months).
- Eunis A2.111: 17,880 m^2; 'Barren littoral shingle'; no intolerance to disturbance.

19.6.45 This 30m zone would not encroach into the area that supports the local *Corallina* turf interest and, at is nearest point, would be some 40m from the habitat supporting that interest.

19.6.46 The works would be temporary and no permanent loss of habitat would occur.

19.6.47 The biotopes directly involved in these temporary works, and listed above, would recover within a reasonable timespan from the disturbance generated by the works. Each is widespread locally and typical of this part of the Bristol Channel.

19.6.48 Whilst the loss of some areas of biotope would occur while this construction zone is in use, given the relatively short duration of the works and the generally high level of recoverability involved, this suggests that sensitivity is low. Given that a frontage of approximately 750m long will be disturbed, the magnitude of the effect is considered to be medium. A **minor adverse** impact is thus predicted.

IMPACT: Disturbance to Corallina due to Construction of the Seawall

19.6.49 The observed distribution of the *Corallina* biotope shows that the nearest occurrence is approximately 75m from the site of the proposed seawall. Given the distance between the seawall and the presence of *Corallina* it is considered unlikely that the seawall works would have the potential to impact upon this interest. As a consequence, **no impact** on *Corallina* as a result of the construction works for the seawall is anticipated.

IMPACT: Intertidal Disturbance Associated with Delivery of Rock Armour for Sea Wall

19.6.50 Two layers of rock armour (total thickness 2.5m, nominal rock diameter 1.35m, median rock mass 6.54t) will be placed at the toe of the sea wall in order to protect that toe from scour and beach lowering. This armour will be placed along a frontage of approximately 760m. Rock armour would be delivered by barge directly to the Hinkley frontage and temporarily placed seaward of the works area to provide protection during sea wall construction.

19.6.51 Vessels grounding on the shore as the tide falls may cause some physical damage to that shore but this will be limited to localised abrasion on initial grounding and the subsequent presence of that passive mass over the surface over the low tidal period. Damage to physical and ecological receptors would generally be minor, with one potential exception: if the activity were to occur over areas of *Sabellaria* colony, loss of localised elements of reef within the berthing footprint involved may occur.

19.6.52 Unloading and transport of materials will involve the movement of vehicles across the shore. If this were to involve the areas of limestone/shale platform, compaction and subsequent erosive loss of the area could be presumed. If this were to involve areas of *Sabellaria* reef, loss of that reef within the affected area could be presumed. Again if this activity were to extend within the limestone shale platform areas, an impact on the *Corallina* interest could be presumed, both through direct loss or compromise to the longshore drainage channels which support that particular interest (for each of these interests, see Ref.19.55 and **Figure 19.36**).

19.6.53 To avoid physical disturbance to sensitive habitats due either to the grounding of barges or the passage of vehicles, a graphical analysis was been completed in order to constrain the berthing activity to a relatively insensitive intertidal area. The need was to avoid interference with both physical features (most obviously the widely distributed cross-shore rock platforms that are typical of the Hinkley Point frontage) and the potentially sensitive biotopes (both the *Corallina* interest associated with these same rock platforms plus *Sabellaria* reef – see Ref. 19.55), whilst also finding an area of the shore whose topography and surface would be suitable for the operation involved.

19.6.54 **Figure 19.36** shows the intertidal area selected. The barge landing area is largely coincident with the historical graving dock associated with the construction of the substantial HPA/B cooling water intake structure currently positioned offshore. It would be limited at its eastern and western boundaries by rock platform habitat, and on its downshore boundary by *Sabellaria* reef. As a precautionary measure, no vessel would be permitted to come to ground outside an inner perimeter set back 50m from each of these boundaries. This would permit flat bottomed barges to be brought close to shore during a high tide, permitting them to ground over the subsequent low water period and be unloaded, without damaging potentially sensitive receptors.

19.6.55 The biotopes associated with this area (inner zone only) are (areas rounded to nearest 10 m^2 and indications provided of recoverability from MarLIN database: http://www.marlin.ac.uk/):

- Eunis A1.32; 1,757 m^2; ‘Fucoids on variable salinity rock’; high recoverability (full recovery within about 5 years).
- Eunis A1.321; 248 m^2; ‘[*Pelvetia canaliculata*] on sheltered variable salinity littoral fringe rock’; moderate recoverability (full recovery up to 10 years).
- Eunis A1.322; 1,368 m^2; ‘[*Fucus spiralis*] on sheltered variable salinity upper eulittoral rock’; high recoverability (full recovery within about five years).

- Eunis A1.323/A1.326; 4,668 m^2; [*Fucus vesiculosus*] on variable salinity mid eulittoral boulders and stable mixed substrata/[*Fucus serratus*] and [large *Mytilus edulis*] on variable salinity lower eulittoral rock; high recoverability (full recovery within about 5 years).
- Eunis A1.46; 415 m^2; 'Barren rock' or 'hydrolittoral soft rock'; no intolerance to disturbance.
- Eunis A2.111; 3,255 m^2; 'Barren littoral shingle'; no intolerance to disturbance.
- Eunis A2.431; 3,097 m^2; Barnacles and [*Littorina spp.*] on unstable eulittoral mixed substrata; high recoverability (full recovery within about five years).

19.6.56 In practice, the actual area of impact will be very much more limited than the areas above suggest, determined by the actual berthing location chosen within this barge landing area on the basis of navigational practicability, and the route taken by vehicles between the sea wall construction zone and the grounded barge. The most likely berthing area within the restricted zone is characterised as Eunis A1.46, described by MarLIN as having no intolerance to disturbance.

19.6.57 Whilst the loss of some areas of biotope will occur while this barge berthing area is in use, the relatively short duration of the works and the generally high level of recoverability involved suggests that sensitivity is low. Given that, as a worst case, a moderate area of the intertidal shore may potentially be disturbed, the magnitude of the effect is considered to be medium. A **minor adverse** impact is thus predicted.

IMPACT: Disturbance to Subtidal Habitats during Construction of Vertical Shafts for the Cooling Water System

19.6.58 Drilling of the shafts would physically disturb sediment on the estuary bed. The method of anchoring during a wet drill approach would result in varying degrees of disturbance; for example, simple anchors would result in a lesser impact than those requiring piling, and the drilling of these would disturb bottom sediments.

19.6.59 The level of seabed sediment scour around the construction-site is likely to be sufficient to remove the 2m of silt overlying the rock surface locally. Given the existing tidal and sediment transport regime this impact, in sediment transport terms, will be of little consequence.

19.6.60 The main impact of this disturbance would be a localised alteration in habitat type away from soft mud to exposed rock. The scale of this disturbance in relation to the widespread nature of the existing muddy plain that extends widely around this location would be inconsequential and, thus, its magnitude would be very low. Given the continual process of tidally driven suspension, deposition and re-suspension normal to the local muddy plain, the sensitivity of the receptor is also very low; resulting in an impact of **negligible** significance.

IMPACT: Disturbance to Subtidal Habitats due to Increased Suspended Sediments Associated with the Construction of the Vertical Shafts

19.6.61 It is considered highly unlikely that the drilling works would produce levels of suspended solids or bedloads that would, beyond a distance at most a few hundred meters downstream of operation, be greater than levels that occur under natural conditions. For both the local infauna and epifauna as well as the estuarine fish populations, already selected by the prevailing conditions of extreme turbidity, this suggests both a low magnitude effect and very low sensitivity. As a consequence a **negligible** impact is predicted.

IMPACT: Subtidal Habitat Disturbance due to Capital and Maintenance Dredging

19.6.62 As noted in **Volume 2**, **Chapter 17**, the operating face of the jetty head will be aligned with the direction of ebb/flood tidal currents in the vicinity. A berthing pocket immediately associated with that operational area will be dredged in order to allow safe delivery of materials across a range of tidal conditions. This dredged area is estimated to be 160m in length and 27m in width with sediments removed to a uniform depth of around 3.5m below the existing seabed (4.5m below CD).

19.6.63 The benthos of this area is typical of the extensive muddy plain that makes up most of the local seabed. Population densities are low due to the extreme tidal conditions. All species identified are commonly found at a national level. The biotope concerned is *'Nephtys hombergii* and *Macoma balthica* in infralittoral sandy mud', also described as 'mobile circalittoral sandy mud supporting a sparse faunal compliment', a biotope which covers approximately 76km^2 out of the total of 94km^2 surveyed locally (**Figure 19.18**, Refs. 19.14 and 19.25). The habitat type which is likely to be affected in this instance is thus locally common and widespread with no protected species; as a result the magnitude of the effect would be low.

19.6.64 Given the existing tidal regime and the associated processes of sediment suspension, mobilisation and deposition, any observable impact due to dredging in this chronically disturbed environment is expected to be of short duration.

19.6.65 As with the area around the cooling water headworks, the predominant epifauna within the area is the brown shrimp *C. crangon*. As with other mobile species, *C. crangon* would be able to move away from the area to seek suitable nearby habitat if need be. In the areas of disturbance both within the berthing pocket area itself and around its margins, a typical faunal assemblage would very quickly become re-established due to tidal mobilisation of surface sediments. Even in less dynamic systems the evidence from studies of recovery rates in subtidal benthic communities of the type present within the footprint of the works clearly demonstrates that soft-sediment, bivalve-annelid dominated communities are able to recover from disturbance events within one to two years (Ref. 19.161). As a result the sensitivity of this habitat to disturbance is considered to be low.

19.6.66 On this basis the significance of the impact is assessed as **minor adverse**.

iii. Changes in Water Quality

IMPACT: Subtidal Habitats due to Spread of Contaminants during Dredging

19.6.67 Capital and, potentially, maintenance dredging, will be required at the seaward end of the jetty to establish and maintain a berthing pocket. Dredging will mobilise sediments and re-suspend particulates in the water column, leading to a temporary and localised increase in suspended solids concentrations and a potential reduction in water quality. Information on existing contaminant loadings within the sediment to be dredged (see **Volume 2**, **Chapter 18**) indicates that there would be a negligible effect on water quality through the mobilisation of this material and thus a **negligible** impact on the local ecology.

IMPACT: Corallina due Changes in Water Quality Associated with Dredging

19.6.68 Although this dredging activity will occur in relatively close proximity to the low water mark and the *Corallina* run-off areas of the lower shore, given the existing tidal regime, any suspended solids in excess of normal levels would largely be advected by the tides and carried elsewhere. A very low magnitude effect would be expected on the *Corallina* run-off feature (i.e. it is expected that the receptor would experience little or no degradation and disturbance is likely to be within the range of natural variability). The sensitivity of the receptor can be regarded as high, on a precautionary basis, given that it is a notable community under the SAC designation. However, given the intermittent presence of the identifiable habitats and their distance from the works, and the fact that *Corallina* is locally selected by the prevailing turbidity regime, in this case its sensitivity is judged to be low. Consequently, the significance of this impact would be **negligible**.

IMPACT: Sabellaria due to Changes in Water Quality Associated with Dredging

19.6.69 Advice provided in Section 5 under Regulation 33(2)(a) of the Habitats Regulations (Ref. 19.114) identifies that *Sabellaria* reef has a moderate level of vulnerability to changes in concentrations of suspended solids. As with *Corallina*, however, *Sabellaria* is locally selected by the prevailing turbidity regime.

19.6.70 The site of the berthing pocket is located greater than 500m away from any areas of intertidal *Sabellaria* reef. Hence, the likelihood of *Sabellaria* being impacted by an increase in suspended solids that would be sufficient to have an adverse effect upon this species is considered very low. The receptor value is nevertheless high as *Sabellaria* reef is an Annex I Habitat, although it's sensitively is considered to be low in this environment. Overall, given the lack of *Sabellaria* in close proximity to the jetty, a **negligible** impact is predicted.

IMPACT: Subtidal Habitats due to Drilling of the Vertical Shafts for the Cooling Water System

19.6.71 During drilling the excavated materials will be mixed with seawater prior to being separated at the water surface. Cuttings with particles larger than 100 microns will be diverted to a barge and sludge re-injected until it reaches a limiting density, at which point this will be diverted to a sludge treatment barge. Filtering would separate solids and seawater, with the seawater being recycled and then released back into the Bristol Channel.

19.6.72 During the drilling works, some sediment from beneath the mobile sediment layer may potentially be disturbed and re-suspended. The volume of sediment likely to be mobilised in this manner is expected to be negligible within the context of existing suspended sediment and bedload concentrations.

19.6.73 The available data show that contaminant levels within the area are relatively evenly spread due to the dynamic tidal flow conditions and regime of continuous re-suspension. This understanding is described in **Volume 2**, **Chapter 18** on Marine Water and Sediment Quality. In this context, and given the low volumes that would be involved, it is anticipated that the impact of any remobilised contaminants on water quality would be negligible. Thus the consequence for the local marine ecology would be a low magnitude effect, set against a very low sensitivity, likewise suggesting an impact of **negligible** significance.

IMPACT: Discharges Associated with the Drilling of the Cooling Water and Fish Recovery Return Tunnels

19.6.74 A variety of discharges will arise from the construction-site, as described below. An offshore discharge location will only become available when the HPC cooling water (CW) system is commissioned; until that time an alternative temporary discharge route has been identified. The impact of commissioning discharges is not described here, but is considered later within this Chapter in the context of the Operational Impacts. The sections below summarise the waste streams involved (greater detail can be found in **Volume 2**, **Chapter 18**) and concludes with an assessment of the consequence of use of the temporary discharge route for marine ecological receptors.

19.6.75 Three main cooling water tunnels will be driven from the land under the seawall, intertidal shore and seabed using dedicated Tunnel Boring Machines. In addition, a further shorter and narrower tunnel will be driven, again from landward, under the seawall and intertidal shore in order to provide a discharge route for the proposed Fish Recovery and Return (FRR) system (described in detail in **Section 19.8** below on mitigation measures).

19.6.76 Some detail of the waste arisings from the cooling water tunnelling operation are described here but quantifications are not yet available for the similar, but very much smaller, FRR operation. For the purpose of this assessment it is taken that the waste arising from that smaller but immediately local operation will be dealt with in precisely the same manner as the cooling water tunnel arisings and will thus not alter the assessment outcome below.

19.6.77 Tunnelling arisings will be recovered to land where they will be treated to separate waste solids from waste water and drilling fluids.

19.6.78 In practice, bentonite-based drilling mud will only be used if geological conditions prove difficult. Consequently a precautionary approach has been taken here which assumes use of the mud-assisted drilling method.

19.6.79 The volume of extracted material in drilling these tunnels would be approximately 577,000m^3 to 650,000m^3 depending on the expansion factor used. While the tunnel machine digs, any bentonite slurry would be sent to the cutting face, become loaded with materials and would then be returned to a separation unit where it would be treated to remove drill cuttings. Dilution water would need to be added to any bentonite and the volume needed for this would be about 60m^3 per hour for the three tunnels, therefore a similar quantity would need to be discharged. This drilling waste could include release of drilling compounds such as bentonite and other chemicals (e.g. organic polymer and residual salt compounds following pH control). Current estimates are that such waste water would contain up to 1,000mg.l^{-1} suspended solids (including 5% bentonite) and 0.7ppm of organic polymers.

19.6.80 These discharges would go to sea via the discharge structure established at the top of the intertidal area. Design studies have considered a number of potential single and multiple outfall configurations and these were tested using a hydraulic model in order to investigate their possible impact on the intertidal shore. The configuration that was selected through that modelling exercise was a single outlet that would result in a relatively confined effluent stream discharge route across the intertidal shore, to the eastern flank of the one-time HPA/B graving dock. This routing will avoid any cross-shore spillage intersecting with sensitive features, such as the longshore drainage routes associated with *Corallina*.

19.6.81 Thus at no point will this discharge route intersect with the *Corallina* interest either directly or via long-shore drainage channels. As noted in Appendix 19A, the influence of suspended solids would have **no impact** on the local *Corallina* and *Sabellaria* interests, and any fresh water input involved would have **no impact** upon the local *Corallina* interest and have **negligible** impact upon *Sabellaria*.

IMPACT: Sewage, Dewatering and Surface Drainage

19.6.82 Sewage and associated wastes associated with the construction workforce will be treated to a tertiary level via package treatment plant prior to discharge, providing a high quality of effluent at point of discharge to the shore. Further details are provided in **Volume 2**, **Chapter 18**.

19.6.83 Surface drainage from the site together with dewatering effluent from the HPC Development Site will also, further to interception, be put to the cross-shore discharge. The base characteristics will be low salinity water plus suspended solids. Again, further details are provided in **Volume 2**, **Chapter 18**.

19.6.84 The discharge of these various waste waters has the potential to impact upon intertidal ecology via their variable salinity, suspended solids composition, and volume.

19.6.85 The high suspended sediment concentration could potentially cause smothering as a result of accretion of fine sediment. Data from existing sources indicate that suspended sediment concentrations in surface waters in the nearshore zone are typically in the order of 250mg/l but can be as high as 1,000mg/l – see **Volume 2**, **Chapter 18**.

19.6.86 As noted above, these discharges would go to sea via the discharge structure established at the top of the intertidal area. Design studies have considered a number of potential single and multiple outfall configurations and these were tested using a hydraulic model in order to investigate their possible impact on the intertidal shore. The configuration that was selected through that modelling exercise was a single outlet that would result in a relatively confined effluent stream discharge route across the intertidal shore, to the eastern flank of the one-time HPA/B graving dock. This routing will avoid any cross-shore spillage intersecting with sensitive features, such as the longshore drainage routes associated with *Corallina*. **Figure 19.19** shows the course of that modelled effluent stream discharge route in relation to biotope mapping, and **Appendix 19A** provides further information on the range of options examined and the allied assessments of impact upon the local marine ecology.

19.6.87 **Figure 19.19** shows both the modelled cross-shore drainage from HPB and a modelled flow pattern associated with the planned discharge structure. At times of low water, the existing discharge, entirely of surface water run-off, crosses a variety of intermediate intertidal biotopes before reaching the lower shore and percolating through an extensive downshore slope of low grade *Sabellaria* reef. The proposed discharge will flow downslope further to the east, firstly across 'barren littoral shingle' biotope then, in turn, '*Pelvetia* on sheltered variable salinity littoral fringe rock', '*Fucus spiralis* on sheltered variable salinity upper eulittoral rock', 'barnacles and *Littorina* spp. on unstable eulittoral mixed substrata', 'hydrolittoral soft rock', and then finally 'a limited downshore extent of '*Sabellaria* reefs on sand-abraded eulittoral rock' – an eastward extension of the same area of low-grade reef currently influenced by the existing surface water drainage.

19.6.88 At no point will this discharge route intersect with the *Corallina* interest either directly or via long-shore drainage channels. As noted in Appendix 19A, the influence of suspended solids would have **no impact** on the local *Corallina* and *Sabellaria* interests, and the fresh water input involved would have **no impact** upon the local *Corallina* interest and have **negligible** impact upon *Sabellaria*.

IMPACT: Corallina due to Discharges Associated with the Drilling of the Cooling Water and Fish Recovery Return Tunnels

19.6.89 Baseline studies have shown that *Corallina* is present within distinctive channels and run-offs along the lower intertidal area, and since any cross-shore discharges could potentially enter these channels and remain there at low tide, a smothering impact is possible. More significantly, a discharge flow might run directly across the *Corallina* run-offs. One of the reasons for the success of the rare *Corallina* run-off biotope on the Hinkley intertidal is the presence of water cover during low tide exposure also allowing high light levels on the alga, a situation not present elsewhere in this region. Excessively high turbidity in discharged water may, if it were to flow towards the *Corallina* run-offs, cause harm. Alterations in salinity, in pH, in turbidity and the presence of organic polymers as well as increased rates of water flow (erosion) are all potentially significant adverse effects on the *Corallina* run-offs. The sensitivity of the algal turf receptor is considered high, but given the mitigation already in place in terms of deliberate placement of the discharge point so as to avoid this particular receptor, the magnitude of any effect is predicted to be very low and the significance of the impact **minor adverse**.

IMPACT: Sabellaria due to Discharges Associated with the Drilling of the Cooling Water and Fish Recovery Return Tunnels

19.6.90 Habitat that supports low grade *Sabellaria* reef of low to medium 'reefiness' is present on the lower intertidal area and so there is some potential for discharge from the upper shore to affect this area. **Figure 19.19** shows that the existing surface water drainage discharge already flows into a wider area occupied by that species. On the basis of this observation together with an understanding of estuarine habit and the turbidity regime to which that species is adapted, the sensitivity of this receptor is considered low. The discharged waters would encroach upon lower intertidal habitat only around the time of low tide, reducing the magnitude of the effect to low and leading to an impact of **minor adverse** significance.

IMPACT: Intertidal due to Sedimentation Associated with Discharges

19.6.91 The volumes and suspended solids involved in this discharge may alter the pattern of sedimentation within the modelled area of flow across the intertidal shore. This influence will compete with those of wave and tide, which will in turn rework any materials added or displaced. As the biotope map shows, a significant part of the route of flow will be over rock and shingle and only a limited area involves 'mixed substrata' – predominantly limestone cobbles mixed with mud and sandy mud. The impact of variable flow plus suspended solids is thus considered to be of low magnitude and the biotopes involved of low sensitivity; suggesting that a **minor adverse** impact would arise.

IMPACT: Intertidal due to Salinity Associated with Discharges

19.6.92 The discharge will be of variable salinity. Surface water drainage and dewatering water will be of low salinity whilst waste water arising from the tunnelling activities is likely to be variable. As noted above, the existing biotopes which will be crossed by this discharge are frequently described as of 'variable salinity' – or are bare rock or barren shingle; the lower shore is occupied by *Sabellaria*, the potential impact on which has already been discussed. On this basis, the sensitivity of the wider intertidal fauna and flora that might be harmed in this instance is considered to be low, and the magnitude of the effect is predicted to be low; hence a **minor adverse** impact is predicted.

IMPACT: Fish due to Increased Suspended Solids Associated with Discharges

19.6.93 Any increase in local suspended solids concentrations associated with these discharges will have the potential to decrease water quality in the vicinity. This could affect fish that may be present in the water column. As discussed previously, the fish assemblage is inevitably well adapted to the existing high turbidity regime and any such alterations to this regime would thus appear to be inconsequential.

19.6.94 While the suspended solids levels associated with the discharge may at times be above background levels, dispersion to background levels would occur over a relatively short distance, suggesting a low magnitude effect. Given that fish are also mobile and would be able to move rapidly out of any waters that are of poor quality, their sensitivity is regarded to be low. Hence the significance of the impact would be **minor adverse**.

IMPACT: Corallina due to Construction of the Seawall

19.6.95 During construction of the seawall there are a number of activities and processes that may lead to a reduction in water quality (as a result of the discharge of potentially contaminated water across the intertidal). The excavation footings for the foundation of the seawall may need to be dewatered and discharge onto the upper intertidal area is likely to be the main route of disposal. This discharge and the excavation works may lead to a localised increase in suspended sediment concentrations.

19.6.96 The location of the seawall works on the uppermost part of the shoreline and largely above MHWS, suggests that the potential for any significant effect on water quality and in turn on the local ecology in the nearshore zone is unlikely. Under high tide conditions, any discharges from the construction area, even if containing relatively high suspended sediment concentrations, would be rapidly dispersed and it is anticipated that background conditions would be achieved close to the points of discharge.

19.6.97 Under low tide conditions, discharges across the upper intertidal area are likely to infiltrate the existing substrates (as they are permeable) and any fine sediment would be anticipated to be washed into the upper beach fabric or deposited in existing areas of mud. Although this depends on the volume of the discharges, it is considered unlikely that they would be of sufficient strength to reach the *Corallina* community present on the lower-mid shore. Even if the discharge were to reach this area and the drainage collected in channels containing *Corallina*, very similar events are understood to occur naturally with rainwater draining off the intertidal area. With the effects of tidal shear these materials would quickly be re-suspended and dispersed. Little impact is thus envisaged on the wider ecology of the shore.

19.6.98 Taking these aspects into consideration, the magnitude of the effect on intertidal communities, and in particular *Corallina*, is thus predicted to be very low. *Corallina* is known (MarLIN) to be moderately well adapted to the periodic natural exposure to extreme salinity variations. It is, however, considered to be of high value in conservation terms. Consequently, the significance of the impact is assessed to be **minor adverse** for this receptor.

IMPACT: Sabellaria due to Construction of the Seawall

19.6.99 Extents of low to medium ‘reefiness’ grade *Sabellaria* reef are present on the lower intertidal several hundreds of metres away from the proposed seawall construction area on the upper shore (**Figures 19.8-10**). It is thus unlikely that any discharge from the seawall construction works would reach the lower intertidal areas supporting *Sabellaria*; even should it do so any such discharge would be diluted or greatly dispersed. **No impact** on this conservation interest feature is thus expected (potential in-combination effects are considered in **Section 19.7** below).

IMPACT: Fish due to Construction of the Seawall

19.6.100 While fish may be present in the vicinity of the discharged waters, it is not anticipated that they would be affected by the discharges as they are fully mobile and able to respond rapidly to an adverse increase in either suspended sediment concentration levels and/or contaminant levels. Given their mobility, **no impact** with respect to fish populations is anticipated.

iv. Noise and Vibration

d) Introduction

19.6.101 A number of construction activities have the potential to generate a significant increase in background noise and vibration levels in marine waters. These aspects of the construction works include: the drilling works for the intake and outfall shafts, construction, operation and dismantling of the temporary jetty and construction of the seawall. No noise and vibration is likely to be caused by land based drainage.

19.6.102 The potential marine receptors are fish and marine mammals, both of which are known to be sensitive to noise disturbance. As a result, both the sensitivity of fish to noise and the scale of noise that might be involved have been reviewed (Ref. 19.56) and as described earlier in this chapter, following recent guidance from JNCC (Ref. 19.155), an array of underwater acoustic sensors has been established both local to the site and on a transect offshore in order to characterise the cetacean interest (Ref. 19.57).

19.6.103 During construction of the shafts for the intake and outfall tunnels the main sources for the generation of noise and vibration will be any piling works and vessel movements around the construction areas themselves. There is no information currently available regarding the types of piling expected to be used (e.g. impact, rotary or vibro piling) so for the purposes of this assessment, as a worst case, it is assumed that percussion piling will be used. Vessel movement noise will be generated regardless of whether piling is used or not.

19.6.104 For the temporary jetty, piling works as well as general construction works would be the main sources of noise and vibration during construction and vessel noise during construction. Details of the construction methodology for the temporary jetty are presented in **Volume 2**, **Chapter 3**.

19.6.105 General activities, including the re-profiling of the cliff face, will generate noise during construction of the seawall. However, given that these works would occur above MHWS the potential for causing an effect to marine species sensitive to acoustic disturbance within the water column is considered negligible. As such the potential impact of noise generated during construction of the seawall is not considered any further in this assessment. The potential effect of noise disturbance on birds that may be utilising the intertidal area during construction of the seawall and the aggregate jetty is covered in **Volume 2**, **Chapter 20** on Terrestrial Ecology and Ornithology'.

Piling Noise – Intake and Outfall Structures and Temporary Jetty

19.6.106 No specific values for the predicted noise levels which could be generated by pile driving during the construction phase for the proposed HPC are yet available as this depends on the technique and equipment to be used. However, a number of previous studies have examined noise levels during construction of coastal developments requiring pile driving. Pile driving has been found to generate sound pressures significantly greater than 192dB re: 1µPa (Ref. 19.162) (Note: the SI unit for the measurement of sound in water is decibels relative (dB re:) to a reference pressure (1µPa)). The level of sound generated can vary in relation to different factors including the size of piles and the scale of the operation (Ref. 19.163).

19.6.107 Studies reported in Ref. 19.164 measuring the sound levels associated with percussive piling found variation in peak to peak pressure changed from 195dB at the pile driver, to approximately 152dB at a distance of about 240m, with a linear decline in sound pressure with distance (measured in metres). 150dB is considered the safe threshold for no physical effects.

19.6.108 The same study (Ref. 19.164) found that at a distance of about 400m from the source of the sound no signal of vibratory piling could be detected, as it was drowned by shipping noise. It also found no evidence that trout reacted to vibro-piling at even a close range of less than 50m. It is probable that the lack of behavioural responses was largely due to the sound energy from the piling being at frequencies at which the fish were relatively insensitive.

Noise Associated with Drilling Works

19.6.109 As described in **Volume 2**, **Chapters 2** and **3** of this ES, a series of three cooling water tunnels will be dry bored from land under the seawall and seabed, in the dry, and two vertical shafts will be wet drilled offshore to meet each of these. In addition a single shorter tunnel to service the FRR discharge will be bored, again from land, to exit in the near subtidal.

19.6.110 No explicit information is available on the level of sound that might be associated with the wet drilling operation, but it is expected that the sound levels involved will be similar to those associated with allied piling activities, and thus have a range of influence of a few hundred meters at most (Ref. 19.56).

19.6.111 The three main cooling water tunnels will be bored by dedicated Tunnel Boring Machines at a depth of between 20 and 40m below the seabed, through a solid rock geology. As a result very little noise is expected to reach the marine environment.

19.6.112 The FRR tunnel will be bored at depth under the seawall and intertidal shore; again, very little if any noise would be expected to reach the marine environment.

Vessel Noise during Construction of the Cooling Water System, Dredging Works for the Temporary Jetty and Operational Traffic using the Temporary Jetty

19.6.113 The construction of the vertical shafts for the intake and outfall structure is likely to require a variety of vessels to move platforms and associated equipment into place, collect discharges, collect and transport drill cuttings and other waste materials, and supply plant and personnel to site.

19.6.114 Capital dredging and possibly maintenance dredging will be required for the berthing pocket at the end of the temporary jetty.

19.6.115 Very large tankers and container ships can generate sound levels in the range 180-190dB re: 1µPa at 1m which is similar to that generated by pile driving (Ref. 19.165) although for smaller vessels the potential impact is greatly reduced. **Table 19.21** shows the sound frequencies and source levels produced by various vessels that may be required during the construction of the proposed development.

Table 19.21: Vessel Sound Frequencies and Source Levels

Vessel	Frequency (Hz)	Source level (dB re 1µPa @ 1m)
Supply vessel	20 – 1,000	110 – 135 (without thrusters) 121 – 146 (with thrusters)
Fishing boat	250 – 1,000	151
Tug (pulling empty barge)	37 – 5,000	145 – 166
Tug (pulling loaded barge)	1,000 – 5,000	161 – 170
Twin diesel work boat	630	159

19.6.116 Ref. 19.165 provides a review of underwater noise in relation to marine dredging and construction activities. Generally, noise generated by dredgers depends on the type of vessel and the activity that is being undertaken. A study by Cefas (Ref. 19.166) of sound levels generated during aggregate dredging found that sound pressure levels were generally found to fall below the ambient noise level (100dB re 1~Pa) within 25km, however some dredging vessel activities were found to emit strong tonal sounds which were detectable at distances greater than 25km. Low frequency sounds were found to be generated by the dredger maintaining its position. Higher frequency sounds (>2kHz) were generated by full dredging activities whilst maintaining position.

19.6.117 Large vessels can cause an aural and potentially a visual disturbance for fish. Generally, vessel noise can elicit avoidance or attraction responses in fish at very low or very high frequencies (Ref. 19.167). Some behavioural changes have been observed in fish in relation to vessel noise such as forming tighter formations, avoiding noise sources and increasing swimming speeds (Ref. 19.168). Experimental studies have shown that avoidance occurs at 118dB within the range of 60 – 3,000 Hz (Ref. 19.169).

19.6.118 There are already large vessels operating within the Severn Estuary/Bristol Channel and fish and marine mammals are likely to have become accustomed to a background level of underwater noise resulting from these activities. In addition, fish and marine mammals have the ability to move away from the sources of vessel noise. As the UK BAP species are all marine migrants moving through the Hinkley Point area from the Bristol Channel, Irish Sea and further afield it would be expected that they would be frequently exposed to vessel noise during their lifetime. Young-of-the-year migratory Annex II species (Atlantic salmon, twaite shad, allis shad, river lamprey, sea lamprey) passing through the estuary, however, would be less acclimatised to vessel noise because of their age.

Effect of Construction Noise on Fish

19.6.119 In order to assess potential impacts of noise on fish an understanding of the hearing abilities of fish is required (see **Table 19.22**). Fish use three organs to detect sound:

the lateral line, the ear and the swim bladder. The presence/absence and characteristics of these organs determine the hearing abilities of fish species which can be considered to be hearing non-specialists, specialists or generalists (Ref. 19.170 and 19.171). Non-specialist fish are those with no swim bladder e.g. lamprey, plaice, dab and sole. Clupeiformes (e.g. sprat, herring and shad) fall within the specialist category and as such can hear sounds over a far greater range than other species (e.g. Ref. 19.172). Species of conservation importance which are considered to be hearing generalists, and are potentially present near the study area, include salmon and eel.

Table 19.22: Hearing Frequency Range for Fish Species of Conservation Importance in the Area around Hinkley Point (Ref. 19.164)

Common Name	Legislative Protection	Hearing Category	Frequency Range (Hz)	Hearing Threshold Range over this Frequency Range (dB re 1μ Pa)
Atlantic salmon, *Salmo salar*	Annex II and V (Habitats Directive) UK BAP	Generalist- swim bladder	30-350	95-130
Shad – Twaite shad, *Alosa fallax*	Annex II (Habitats Directive) UK BAP	Specialist	30,000-60,000	190-198
River lamprey, *Lampetra fluviatilis*	Annex II and V (Habitats Directive) UK BAP	Generalist- no swim bladder	Unavailable	Unavailable
Sea lamprey, *Petromyzon marinus*	Annex II (Habitats Directive) UK BAP	Generalist- no swim bladder	Unavailable	Unavailable
Sea trout, *Salmo trutta morpha trutta*	UK BAP	Generalist-swim bladder	30-350	95-130
Common or Sea Sturgeon, *Acinpenser sturio*	Annex IIa and IVa (Habitats Directive), UK BAP Bern Convention Appendix III, CITIES Appendix I, WCA Sch. 5	Potential specialist	100 – 2000	Unavailable
Eel, *Anguilla anguilla*	UK BAP	Generalist- swim bladder	10-300	Unavailable
Cod, *Gadus morhua*	UK BAP	Generalist- swim bladder	10-500	65-140; /75-110; /95-120
Herring, *Clupea harengus*	UK BAP	Specialist	20-4,000	75-135
Dab,	UK BAP	Generalist- no	30-200	90-105

Common Name	Legislative Protection	Hearing Category	Frequency Range (Hz)	Hearing Threshold Range over this Frequency Range (dB re 1μ Pa)
Limanda limanda		swim bladder		
Sole, *Solea solea*	UK BAP	Generalist- no swim bladder	Unavailable	Unavailable
Plaice, *Pleuronectes platessa*	UK BAP	Generalist- no swim bladder	Unavailable	Unavailable
Whiting, *Merlangius merlangus*	UK BAP	Generalist – swim bladder	Unavailable	Unavailable

Note: *Where species data are lacking, data for those of similar physiology are presented where possible.*

19.6.120 In addition to auditory problems, more severe impacts could include the perforation of swim bladders by high-energy underwater noises (Ref. 19.173) which can cause fish to sink, lose the ability to orientate themselves, or lead to internal bleeding and fatality. Noise levels within 5m of pile driving operations can exceed levels that can harm or kill fish, with peak values quoted at around 218dB. The sound pressure levels which may cause harm to fish differs between species and is largely dependent on the presence or absence of a swim bladder. Underwater noise may also create disturbance to local fish populations, although fish will rapidly acclimatise to background noise (Ref. 19.56).

19.6.121 Audiograms (see **Table 19.22**) indicate hearing ranges for some of the species of conservation importance known to be present within the Severn Estuary/Bristol Channel (Ref. 19.164).

19.6.122 Of particular importance in the Severn Estuary are populations of migratory salmon and shad that may be migrating through the estuary during the works. Salmon are only sensitive to low frequency sound and do not react to frequencies above 380 Hz. The lowest response threshold and presumably the frequency of greatest sensitivity are between 100 and 160 Hz. Above this sensitivity rapidly declines. Vibratory piling produces sound within the range of frequencies detectable by salmon.

19.6.123 Shad are clupeids (a family of fish also including herring, sardine and menhaden), and as such it could be considered that they are morphologically very similar to the Atlantic herring (*Clupea harengus*). Studies on American shad *Alosa sapidissima* found shad could detect sound from 200 Hz to over 180,000 Hz, although the two regions of best sensitivity ranged from 200 to 800 Hz and the other from 25 to 150 kHz (Ref.19.174), with the lower bandwidth similar to that reported in herring by Ref. 19.175. It has been suggested that there are subtle differences in the ears of Clupeinae and Alosinae that may provide a mechanical explanation for why only the shads are able to detect ultrasound (Ref. 19.172).

19.6.124 Data on the response of allis shad to sound are limited, however data on the closely related twaite shad indicate noise levels of 158dB and a ramped frequency range of

100 to 500 Hz caused fish to undertake avoidance reactions at 138dB, which was >40dB above ambient noise levels (Ref. 19.176).

19.6.125 Comparing data on vessel noise generation (**Table 19.21**) with the hearing capabilities of the fish species (**Table 19.22**) it can be seen that supply vessels, fishing boats and tugs (pulling empty barges) can generate sound within the hearing frequency range of most species, the only exception being twaite shad. A tug pulling a loaded barge however, can generate sound at much higher frequencies (1,000 to 5,000 Hz) which lies outside the range of the majority of fish species (salmon, twaite shad, sea trout, eel, cod, dab). Similarly the frequency of sound generated by a twin diesel work boat is outside the hearing range of these species.

19.6.126 For fish species to hear the vessels and demonstrate an avoidance reaction, both the frequency and noise level indicated in **Table 19.21** would need to be within the range of a particular species. However, attenuation of sound means that as distance from the vessel increases, noise levels would reach values less than those indicated to be source noise levels in **Table 19.21**.

19.6.127 The impact associated with vessel noise would be expected to be smaller than that associated with pile driving even though vessel noise may be more of a continuous nature. While it might be anticipated that there could be a greater effect due to the combination of vessel plus piling noise, it is considered unlikely that the significance of this cumulative effect would be any greater than for piling alone. This is again due to the fact that any fish within the zone of influence would no longer be present in the affected area or would avoid it while noise levels were raised.

19.6.128 Dredging would only be undertaken for around four weeks during the construction phase and mobile organisms can evade the noise source if required. Consequently, noise impacts associated with dredging are not expected to affect mobile marine ecology receptors.

IMPACT: Generalist (no swim bladder) due to Noise Associated with Piling

19.6.129 Lacking swim bladders, flat fish are deemed to be least likely to be impacted by piling works owing to their weak auditory capacity (restricted to particle motion). Although it is possible that individual fish may be impacted in the immediate vicinity of piling activity, flat fish found around Hinkley Point are widespread and unlikely to be impacted negatively at a population level. The receptor value in this case is considered to be low. The magnitude of the effect is also predicted to be low due to (a) the existing noisy intertidal environment, (b) the fact that at any one time only a very small proportion of the overall population of any one fish species would be likely to be within close proximity to the piling works, (c) the adoption of soft start piling (a gradual increase in noise levels), and (d) the ability of larger fish to swim away from the noise source. The impact significance is therefore predicted to be **negligible**.

IMPACT: Generalist (no swim bladder) due to Noise and Vibration Associated with Dredging

19.6.130 In terms of vessel movements and dredging activities, fish would be present in the vicinity of the dredging for the jetty and therefore, would be directly affected by the noise and vibration associated with the operation of the dredger, which would be temporary. The receptor value is considered to be low, while the magnitude of the effect is predicted to be very low (i.e. it is expected that the receptors would experience little or no degradation as they are generally habituated to vessel noise and disturbance is likely to be within the range of natural variability and limited to areas within and adjacent to the development). The impact of significance is therefore assessed as **negligible**.

IMPACT: Generalist (no swim bladder) due to Noise and Vibration Associated with Construction of Horizontal Tunnels

19.6.131 With regard to drilling noise during the construction of the horizontal tunnels, the depth of the drilling within the bedrock (40-20m depth) suggests that the propagation of sound waves into the water column would be limited. Flatfish, which are sensitive to vibration and low frequency sound, are likely to be able to feel the vibration from the approach of drilling activity through the seabed and would, therefore, have the opportunity to move from the area before noise levels increased. Any avoidance reaction in fish would be likely to be confined to the immediate corridor above the tunnel and it is considered that there would be a very low/negligible sound level within the water column at a distance of >1km from the source.

19.6.132 Thus, for generalist fish species, a low sensitivity combined with low magnitude of effect would have no more than a **minor adverse** impact.

IMPACT: Generalist (swim bladder) due to Noise and Vibration Associated with Piling

19.6.133 There is still considerable uncertainty about the effects of piling noise on migratory fish species, although the available data suggests that levels sufficient to cause serious injury or death are unlikely to occur at distances of greater than 5m from the source, and at greater than 400m it is unlikely that salmon or trout would react at all to vibratory piling. Based on salmonid and clupeid hearing it could be anticipated that migratory fish in the vicinity of piling activities would be expected to show avoidance behaviour to noise levels above 90dB depending on the intensity of background noise.

19.6.134 Anadromous species migrating seaward are unlikely to be prevented from migrating by noise impacts as the size of seaward migrating salmon (smolts), shads and lamprey means that their swimming speeds are typically lower than tidal stream velocities. The movements of juveniles of anadromous species will thus be determined by tidal transport, which means that individuals will tend to pass the area of disturbance fairly rapidly. In the case of salmon smolts, the utilisation of the fastest flowing portion of the estuary would ensure animals are rapidly conveyed past any area subject to disturbance impacts.

19.6.135 The Severn Estuary is a known migratory route and given the designated status and importance of the migratory fish populations the disturbance and potential physical impact of piling could be considered to be of moderate significance. However, given that the Inner Bristol Channel is approximately 20km wide at the point of disturbance and that it is unlikely that elevated noise levels that would lead to avoidance would extend beyond 400m there would be sufficient space for any displaced migratory fish to continue migration. Given the relatively small area of the Inner Bristol Channel that would be impacted during the construction and piling phase it is, therefore, considered that the magnitude of the effect would be low (on a receptor of low sensitivity) and that there would thus be a **minor adverse** impact.

IMPACT: Hearing specialists (swim bladder) due to Noise and Vibration Associated with Piling

19.6.136 The potential impact of noise generated during pile driving would vary depending on the species/assemblage of fish considered. For non-migratory, resident species within the range of the works it is certain that an effect would occur, but that, based on hearing range and sensitivity only species such as herring would be likely to be sensitive to the generated noise levels. For such species, within the immediate vicinity of the piling it would be expected that some disturbance would occur and potentially if fish were within very close proximity to the piling (i.e. within a couple of metres), physical damage could occur. The sensitivity for these species would therefore be high.

19.6.137 It may be presumed that without mitigation individuals would be open to harm if in close proximity to the operations themselves. If percussive piling were to be used without mitigation, the magnitude of the effect would be medium, and the sensitivity of the receptor also medium, with a consequential impact of **moderate adverse** significance.

IMPACT: Effect of Construction Noise on Marine Mammals

19.6.138 As discussed in the baseline section, there is evidence from acoustic monitoring that marine mammals visit the area, however they are not commonly observed and are unlikely to be present on a regular basis in the vicinity of Hinkley Point. For the purpose of this assessment they have been assumed to be intermittently present. The receptor value is considered to be high, as it includes Annex II species of international importance. Impacts are predicted to be direct and temporary, however, due to the limited presence of marine mammals, the adoption of a soft-start approach and their ability to avoid areas of disturbance, the magnitude of the effect is assessed to be very low. Therefore, it is predicted that the impact significance for marine mammals from noise associated with the construction works would be **minor adverse**.

i. Artificial Lighting

19.6.139 The construction works may require that night time working is undertaken, in which case powerful artificial lighting will be needed. This may apply to the drilling works for the intake and outfall shafts, construction and dismantling of the temporary jetty and construction of the seawall. For the purposes of assessment it is presumed that lighting will be required. Lighting will also be required for the temporary jetty during its operation.

19.6.140 The effect of artificial lighting has been considered in relation to two broad habitat types and the species that utilise these habitats – namely intertidal areas and the water column.

IMPACT: Lighting Effects on Intertidal Areas

19.6.141 This effect only applies with regard to the temporary jetty. While it is possible that lighting may be used during construction of the seawall (tidal conditions permitting) there are no intertidal communities of significance (e.g. *Corallina* turfs) within 100m of the location for the seawall.

19.6.142 The invertebrates and plants present on the intertidal are likely to be tolerant to exposure from artificial light as clearly these communities are subject to intense light levels on a daily basis. Artificial lighting would also only have an effect during low tidal conditions, which effectively means that due to attenuation through the water column, communities would not be subject to a 24 hour increase in light levels. Potential impacts on birds are considered in **Volume 2**, **Chapter 20**, Terrestrial Ecology and Ornithology.

19.6.143 Of the *Corallina* dominated biotope present on the Hinkley intertidal only a relatively small area falls within the footprint of the temporary jetty. Within this small area it can also be stated that potential lightfall from artificial lighting would only affect a proportion of the *Corallina* biotope present, as light levels would rapidly drop off away from the source. Although an increase in light levels could potentially promote growth of *Corallina*, it is highly unlikely that the increase that some isolated areas of *Corallina* might be subject to would promote growth such that it was of significance or potentially interfere with other physiological processes. Hence **no impact** is anticipated.

IMPACT: Lighting Effects on the Water Column

19.6.144 In the case of the construction phase, lighting of the works for drilling of the vertical shafts for the intake/outfall structures and for the temporary jetty may influence the water column. Light penetration into the water column will also occur during operation of the temporary jetty.

19.6.145 The key variable to take into account when assessing light attenuation through water is the suspended sediment load of the water. Due to the very high turbidity levels within this area of the Inner Bristol Channel there would be limited penetration of the artificial light into the water column, and it is considered that light levels would be negligible after 1-2m of passage though water. Consequently, only organisms near the water surface may potentially be affected by this night time lighting and benthic organisms on the estuary bed would not be expected to be influenced.

19.6.146 Light is known to have a strong influence on fish behaviour, with photoperiod acting as an environmental cue in relation to reproduction, and also as a factor determining migration. Changes in natural reproductive development rates as a result of artificial light regimes have been demonstrated for a range of fish species. However, this has generally been where the light environment experienced by fish is overwhelmingly determined by that artificial source (e.g. in aquaria, laboratories or fish farm facilities).

19.6.147 Light has also been demonstrated to influence fish migration, with species such as salmon and sea trout migrating predominantly at night rather than day. Similarly, various species have been demonstrated to either be attracted to or repelled by light, with the majority being repelled.

19.6.148 While it is possible that some fish species may be present within the area affected by artificial light, the potential magnitude of change associated with this effect (for the reasons given above) is considered to be very low. Given that it is likely that only a very small percentage of the Inner Bristol Channel would be affected, for both the temporary jetty and the shaft drilling works, and that many species, including migrating fish, would avoid any lit areas and thus be of low sensitivity, the overall effect on fish movement is anticipated to be **negligible** for the construction phase (drilling works and jetty) and operational phase for the temporary jetty.

e) Potential Impacts during Operation

i. Introduction

19.6.149 This section covers the range of impacts that would occur as a result of operational activities. The key aspects and the receptors that these could affect are listed below in **Table 19.23**.

Table 19.23: Key Operational Impacts and Receptors

Receptor	Phytoplankton	Zooplankton	Epifauna	Benthic flora	Subtidal invertebrates	Intertidal habitats (including Sabellaria)	Fish	Marine mammals
Thermal plume impacts			✓	✓	✓	✓	✓	
Chemical plume impacts			✓	✓	✓	✓	✓	
Entrainment and impingement impacts of abstraction on intake screens	✓	✓	✓	✓	✓		✓	

ii. Thermal Discharges

Allied Assessments

19.6.150 The issue of the proposed thermal discharges from HPC is discussed in **Volume 2**, **Chapter 18**. That chapter deals with matters of compliance against specific temperature and allied water quality criteria set down in both regulations and existing guidance. Discussions within this chapter focus solely on the implications of the thermal fields involved on the marine ecology of the system.

Numerical Modelling of Thermal Plumes

19.6.151 The supply of cooling water is fundamental to the operation of any thermal power station and the requirements of a nuclear station are not significantly different from to those using conventional fuels (e.g. coal, oil). HPC is situated on the coast in order to utilise the large volumes of seawater available. In such circumstances the areas potentially most vulnerable to any excess temperature will be the intertidal and shallow water seabed.

19.6.152 The Inner Bristol Channel is subject to both variable freshwater inputs from river estuaries and a variable temperature regime. There may be periods of constant high or low temperature and low salinity during river floods, depending on the season. Therefore, any biological impact will be dependent on a combination of salinity and temperature conditions. More open coastal locations may not be affected by such large salinity and temperature variations, but will be more prone to the effects of weather, wind and waves. For the purposes of both appropriate engineering design and environmental assessment the first step is to secure an understanding of the existing baseline condition over which any proposed discharges will be superimposed.

19.6.153 For HPC, operational requirements determine that at full operating load the cooling water will be discharged at 10 to 12°C above intake, and at full load the cooling water volume involved across both European Pressurised Reactor (EPR) units will be approximately $125m^3.sec^{-1}$.

19.6.154 A continuous supply of cool water is a primary operational requirement. In order to ensure this supply the relative positions of the intakes and outfalls are chosen with considerable care so as to avoid the recirculation of heat during the full range of tidal and meteorological conditions that might be expected. To this extent the needs of the power station operator and the local marine ecology are identical i.e. stable conditions within a limited mixing zone area with efficient loss of excess heat to atmosphere from the sea surface.

19.6.155 To simulate this wide range of hydrodynamic, meteorological and geomorphological conditions the GETM thermal outputs have been used, unless stated otherwise. This model is considered to overestimate water temperature outputs (by approximately 0.5 to 0.75°C); while it is considered that the Delft model was underestimating the extent of the plume. The upper local sea water range temperature of 20.4°C (98 percentile based on 32 years of Cefas data for Hinkley Point) was also used as the basis for a precautionary assessment.

19.6.156 Details of the models employed in support of the HPC development may be found in Refs. 19.59, 19.65, 19.38 and 19.67. A summary of model development is included as **Appendix 18A** to this ES.

19.6.157 Hourly model outputs against a selected set of variables were used to produce time series means and averages. The basic modelling scenarios that were tested, Runs A-E, are described in **Table 19.24**. The runs were used to produce detailed thermal predictions to establish baseline conditions (i.e. HPB operating alone) and to represent a range of potential operating conditions in the future.

19.6.158 In order to establish baseline conditions and validate the model, Runs A and B represent HPB operating at 70% and 100%. The reasons for running variations on the HPB operating scenario relates to a reduction in HPB operating output during the modelling verification and calibration stage. It should be noted that it is not envisaged that operation of HPB at 70% reflects long term operating conditions at HPB. Modelling of HPB between 70% and 100%, however, does provide the ability to assess a range of conditions under which the station could operate both now and in the future (i.e. it reflects a range of current baseline conditions).

19.6.159 Run C calculates the thermal plume conditions in relation to the operation of HPC only (i.e. the effects of HPB are removed). This reflects conditions that would occur in the future when HPB ceases generation.

19.6.160 Run D reflects a time whereby HPC is operating at full capacity and HPB is operating, but potentially below consented maximums (as described above). Run D thus provides the opportunity to assess impacts on the potential lower range of HPB operation.

19.6.161 Run E is considered to represent the upper limit of potential combined operation, i.e. both HPC and HPB are operating at maximum consented levels. For the purposes of the assessment included within this chapter, a five year overlap with HPC is assumed (based on the potential extension of the operational life of HPB).

19.6.162 In summary, Runs A and B are considered to reflect the current baseline conditions experienced at Hinkley Point; while Runs C, D and E reflect potential operating conditions in the future and therefore form the basis of the impact assessment in this chapter, as well as the allied HRA.

Table 19.24: Calculated Thermal Plume Areas at the Bed, for Particular Excess Temperatures

Run	Total plume area km^2 at the bed at particular mean excess temperatures The 2nd value indicates the equivalent plume area once corrected for the time that cells are dry					
	≥0.75°C	≥1.0°C	≥1.25°C	≥1.5°C	≥2°C	≥3°C
Run A Hinkley B (70%)	8.99 4.31	5.88 1.67	4.04 0.56	2.8 0.20	0.71 0.02	0.0 0.0
Run B Hinkley B (100%)	13.58 8.51	9.62 4.71	7.10 2.34	5.18 1.01	3.06 0.20	0.31 0.01
Run C Hinkley C (100%)	51.50 43.7	37.4 27.9	25.77 16.4	18.22 9.54	5.31 2.17	0.0 0.0
Run D Hinkley C (100%)+B (70%)	60.21 54.4	46.26 40.1	35.8 28.7	27.78 19.7	17.95 8.5	3.6 0.20
Run E Hinkley C (100%) + B (100%)	63.83 57.71	49.01 43.38	38.65 32.32	30.50 23.45	19.90 11.17	7.65 0.77

19.6.163 The extent of the thermal mixing zones associated with HPB (which defines the existing baseline) and HPC are illustrated in **Figures 19.20** to **22**.

IMPACT: Thermal Regime Change on Non-migratory Fish

19.6.164 An understanding of the fish assemblages likely to be present in the vicinity of the predicted mixing zone have been obtained from sampling at sea (e.g. Ref. 19.33), from intertidal fish surveys (e.g. Ref. 19.177) and from impingement data collected at HPB (e.g. Ref. 19.36). The dominant species recorded include sprat, whiting, herring, sole and flounder. Both the sampling at sea and the impingement data reveal a wide range of fish species including a number of commercially important species.

19.6.165 Potential impacts on fish assemblages attributable to the discharge of thermal effluent have been comprehensively reviewed by the BEEMS Expert Panel (Ref. 19.21). These may include changes to spawning season, reproductive capacity (Ref. 19.178), feeding behaviour changes and recruitment impacts.

19.6.166 Responses of fish to changes in temperature have been extensively studied in the past, particularly in relation to commercially important species and protected species and in relation to community changes in response to regional climate change (Refs. 19.21 and 19.179). Egg and embryonic life stages may be most at risk from increases in temperature and the significance of this risk will depend in a large part upon their relative abundance within the area and the significance of these larval stages in terms of recruitment, as well as the degree to which they are actually exposed. In practice, recent ichthyoplankton studies carried out off Hinkley Point (Ref. 19.33 and 19.34) suggest that local fish egg and larval abundances are chronically low. Adults would be expected to move away from an area of higher temperature, therefore, reducing the likelihood of exposure.

19.6.167 While fish will undoubtedly be present within the area affected by the thermal plume, the overall effect is difficult to quantify due to the composition of the fish assemblage. Whatever the level of effect on different species it is obvious that fish have the capacity to move in and out of the thermal plume and thus no direct mortality would be expected. It is known that certain species, such as sea bass, congregate near thermal plumes, suggesting that the presence of the thermal plume may be beneficial for this species. Increased temperature may also be beneficial for other Lusitanian (warmer-water) species present in the Inner Bristol Channel, but potentially of some detriment for species nearer the southern extent of their range (Arctic-Boreal or cold-water species) e.g. cod (Ref. 19.21). Given that the predicted warming would cover a relatively small area of the Inner Bristol Channel, the magnitude of the effect is considered to be low. It is apparent that no large-scale changes in the fish assemblage as a result of the predicted temperature change would occur.

19.6.168 There are likely to be small-scale changes in the composition of the epibenthic fish assemblage within the footprint of the thermal plume. But again, as the vast majority of the species present are tolerant to temperature variations within the range predicted for the thermal plume (Ref. 19.14), it is unlikely that any shift in the composition of the assemblage would be significant either within the confines of the affected area itself and certainly not at the Bridgwater Bay-Inner Bristol Channel level. The sensitivity of non-migratory species is therefore low.

19.6.169 Taking the above points into account, whilst it is possible that some small-scale changes to the fish fauna within the footprint of the plume may occur, overall the fish assemblage would retain its existing composition. Only through an Inner Bristol Channel alteration in water temperature would the composition of the fauna be likely to change, as evidenced by the long-term data series collected from the intake screens at HPB (described earlier in this chapter), and such temperature change would not occur as a result of the thermal discharge into a relatively localised area. The conclusion is thus that although temperature sensitivities exist among the fish fauna, the predicted extent and magnitude of the thermal discharge would not lead to significant change in either species composition or population levels in the estuary and, overall, a localised, long-term but **minor adverse** impact would be anticipated.

IMPACT: Thermal Regime Change on Migratory Fish

19.6.170 Migratory fish may be influenced by thermal change through a number of potential pathways (as for other, resident fish), but it is perhaps the potential for migratory behaviour to be affected that is of greatest importance (Ref. 19.21). For those species for which the Severn Estuary is of importance, the following aspects of are significance:

- River lamprey migrate from estuaries to spawn in rivers when water temperature reaches 10 - 11ºC, usually in March and April (Refs. 19.21 and 19.180), however spawning may continue at higher temperatures (Ref. 19.181).
- Sea lamprey usually migrate from the sea and spawn in British rivers in late May or June, when the water temperature reaches at least 15ºC (Ref. 19.182). Adult sea lamprey have been shown to survive in a wide range of temperatures from 4-20ºC (Refs. 19.21 and 19.183).
- Migration of shad from the sea to estuaries appears to be triggered by temperature (Ref. 19.182). Temperature requirements for both twaite and allis shad migration have been shown by a number of workers to be similar and range from 10 - 16ºC (Refs. 19.21 and 19.182). Allis shad eggs have been shown to be sensitive to water temperatures below 16 - 18ºC, therefore it has been hypothesised that climate change may make some British rivers more favourable for allis shad than in the past (Ref. 19.182). Temperature has been shown to affect larvae development and year- class strength, in that temperatures at the higher end of the range have encouraged spawning activity and enhanced subsequent larval survival and growth (Ref. 19.182). Temperature preferences for larvae are dependent on size to some degree with preferences between 17 and 21.5ºC identified by Ref. 19.184 in the Elbe estuary. Overall, an increase in temperature may be beneficial for warm-water species such as shad and lampreys and of some detriment to cold-water species such as salmon (Ref. 19.21).
- Fish are known to migrate into and out of thermal effluent discharges, and it is reported that greater fish abundances can be found at outfall locations than at adjacent locations, however this is influenced by seasonal migrations (Refs. 19.21 and 19.185). The presence of thermal effluent discharges could potentially locally exclude some species with low tolerance to temperature, which may result in local changes in species composition and community structure (Ref. 19.185). The author of Ref. 19.73 demonstrated that salmon migrating at sea and eels in estuaries use temperature fronts, however there appears to be little evidence to suggest that thermal effluent discharges can interrupt migration (Refs. 19.21 and 19.73). The authors of Ref. 19.186 reviewed evidence of thermal barriers to fish and were unable to find firm evidence of the reality of thermal barriers in rivers and estuaries, except near to the lethal limit. There remains potential, however, for avoidance behaviour within some species when undesirable temperatures are encountered, for example sea trout smolts are known to avoid temperature increments of >6°C thermal effluents (Ref. 19.187).

- Sea trout smolts are known to avoid thermal interfaces where the temperature rise is above 6℃ (Ref. 19.237).

19.6.171 Possible thermal occlusion of migratory pathways thus remains one of the primary considerations when assessing thermal effluent effects on diadromous fish. Temperature increases affecting migratory fish species and thermal standards for marine environments are discussed in Ref. 19.21. A maximum uplift of 2°C is recommended for the edge of mixing zones within SACs which include sensitive species such as salmonids; and an uplift of less than or equal to 3°C is recommended for other status classes.

19.6.172 The best practice guidelines for prevention of thermal barriers to fish migration state that no more than 25% of the cross-sectional area of an estuary or river should exceed a temperature of 2℃ above ambient for more than 5% of the year (Refs. 19.31 and 19.186). Hence predicted excesses above ambient were analysed for each of the Transects A to D (**Figure 19.23**) for each GETM Model Run A to E (**Table 19.25**). Analysis of the annual results show that only Transects B (Stolford to Burnham-on-Sea) and C displayed potential failures (**Table 19.25**) (Refs. 19.59, 19.63 and 19.65). However, in both cases there were only a few annual events and neither transect indicated breaches of the criteria for more than 5% of the time and, therefore, neither of the transects failed the criteria.

19.6.173 In the interests of understanding the system and with a view to extending the logic to future climate scenarios when specific meteorological conditions may become more frequent, Transects B and C (**Figure 19.23**) were analysed in more detail. On this basis (see Ref.19.59) the future conditions most likely to produce barriers to fish migration are warm, summer conditions, on spring tides with moderate winds from the west. Even so they are unlikely to exist for more than one or two hours on each tide and only occur on spring tides. It is therefore considered unlikely that the thermal cross sectional area criteria will be breached during the lifetime of HPC.

Table 19.25: Incidence of Hourly Intervals of Occlusion of Estuarine Cross Sectional Area >25% from Annual Analysis (Ref.19.59)

No of Excess Temperature Events where the cross sectional area at >2C is > 25% of the transect						Breach Annual %
Transect	**Run A**	**Run B**	**Run C**	**Run D**	**Run E**	**Run E**
A	0	0	0	0	0	
C	0	0	0	7	28	0.39%
B	0	0	0	0	4	0.05%
D	0	0	0	0	0	
No of Excess Temperature Events where the cross-sectional area >= 2C is in the range 0.1% - 25% of the transect						
Transect	**Run A**	**Run B**	**Run C**	**Run D**	**Run E**	
A	0	0	0	0	0	
C	0	0	0	26	54	
B	157	715	75	766	1461	
D	0	0	0	0	0	

19.6.174 Migratory fish passage is thus not predicted to be hindered in the Inner Bristol Channel, Bridgwater Bay area or the River Parrett and both these water bodies are predicted to remain passable at all states of the tide.

19.6.175 While it is thus possible that the predicted thermal change could lead to an alteration in the behaviour of migratory fish, it is not considered likely that this would have any significant effect on either their ability to migrate or would influence their cues for migration. The expected temperature change would not be sufficient to block migratory pathways through the Inner Bristol Channel towards the Severn Estuary or rivers draining into the estuary (e.g. the Parrett, Wye, Usk). It is clear that the migratory fish populations (both from a conservation and fisheries perspective) are of importance. However, given their overall tolerance to temperature change, their ability to select their preferred temperatures and the relatively localised nature of the predicted >2℃ change, it is considered that the potential magnitude of change is low, and the sensitivity of migratory species is medium. Hence, overall, the impact would be **minor adverse**.

IMPACT: Thermal Plume on Corallina and Sabellaria

19.6.176 Where the thermal plume impinges upon intertidal or shallow subtidal areas, there is likely to be a shift in the zonation of benthic macrofaunal communities as a result of their differential tolerance to temperature rise, upper shore species being more tolerant than lower shore or shallow-subtidal species (Refs. 19.72 and 19.189). Species and communities of the deeper subtidal would not experience temperature rises of an extent likely to have any adverse impact, as they will not suffer any direct contact with the plume-water.

19.6.177 The intersection of the thermal plume with the seabed and intertidal areas, as modelled by GETM, is shown in **Figures 19.24** to **19.26**.

19.6.178 The benthic communities or habitats occurring within the vicinity of the HPC plume include four species that might be of concern if sensitive to an increase in temperature:

- The bivalve *Macoma balthica* on the intertidal flats, as a potentially significant food resource for littoral-feeding birds or demersal fish or decapods.
- The shrimp *Crangon crangon*, a significant food resource for birds and fish, and a significant predator on the intertidal.
- The *Corallina* run-off biotope, as it is both rare in this region (and in the UK) and itself provides a habitat for many other species.
- *Sabellaria alveolata*, a common species but one that produces biogenic reef habitat (again to the benefit for other species) along the lower shore.

19.6.179 Both *Corallina* run-offs and *Sabellaria alveolata* tubes and reefs are present across the Hinkley Point intertidal. *S. alveolata* is a Lusitanian species restricted in its distribution in the UK by winter cold temperatures, and indeed shows the greatest development of reefs within the outflow of the existing Hinkley Point Power Stations. *Corallina officinalis* agg. is naturally tolerant of warmer (and colder) waters than those in Bridgwater Bay, occurring from Norway to Morocco, as well as in mid- to low-shore permanent rock-pools which can be subject to extremes of temperature at low tide.

19.6.180 The modelling outputs predict that the extent of the thermal plume for HPC alone will have no greater influence on the Hinkley shore than that of HPB – see **Figures 19.24** to **19.26** and **Figure 19.27**. This suggests that both existing *Corallina* and *Sabellaria* communities would not be subject to an increase in thermal load and, consequently, **no impact** with regard to these ecological interests is anticipated. While a simultaneous operation of HPC and HPB would result in some increase in average temperatures on the Hinkley frontage, available data on both *Corallina* and *Sabellaria* (e.g. see Refs. 19.14 and 19.73) suggest that such an increase would be unlikely to have any ecological consequence for these species.

IMPACT: Thermal Plume on Macoma balthica

19.6.181 The bivalve *Macoma balthica* is dominant in both intertidal and subtidal infaunal communities at Hinkley Point (Refs. 19.23 and 19.28). This species is also considered to be an important prey item for birds and benthic fish and crustacean species (Ref. 19.14). *M. balthica* has a wide geographic range, with southern limits on the coasts of the Bay of Biscay, although local populations will be adapted to the ambient temperature regime. For example, studies on populations in the Wadden Sea (Ref. 19.190) and in the Baltic Sea (Ref. 19.191), both colder waters than are found at Hinkley, recorded reduced population sizes and increased offshore migration in response to raised temperatures, in the former case over the longer term (possibly a result of climate change) and in the latter case in response to a thermal discharge of 10ºC ∆T.

19.6.182 Studies conducted as part of BEEMS contrasted the condition of *M. balthica* populations across a geographical temperature gradient, finding no relationships between latitude and condition, age or structure of the populations (Ref. 19.50). However, a wealth of literature has shown warmer winter temperatures are associated with reductions in fecundity, recruitment, condition and earlier recruitment (Ref. 19.14).

19.6.183 Growth of *M. balthica* is reported to cease at 15ºC (Ref. 19.192) and its growth period in the Wadden Sea is limited to between the time of first spawning in early spring and the point at which mean temperatures reach 15 ºC. A reduction in growth period may occur with limited food availability and increased summer temperatures. Increased temperatures as a result of the thermal plume could be expected to bring forward the 15ºC growth threshold.

19.6.184 Ref. 19.14 suggests that under an operational scenario of HPB and HPC running together at full capacity a worst case reduction in growth period of approximately five days would occur. Slightly less than half of Stert Flats would be affected by a change in the *M.balthica* growing period for the most extreme scenario (HPB + HPC at full load), whilst Berrow Flats would experience a reduction of 1 day only (2% of its growth period) – see **Figures 19.24** to **19.26**.

19.6.185 Initial studies (Ref. 19.23) were carried as part of the BEEMS programme into the characterisation of populations outside and within the HPB plume. It was found that there were no significant differences in biomass, length or condition between stations inside and outside the area of influence of the thermal plume for any of the survey datasets. However, the surveys upon which this initial finding were based contained only a few sites within the expected intersection of the HPB plume.

19.6.186 Potential impacts of the HPB thermal plume on the Stert Flats *M. balthica* populations were investigated using more detailed seasonal measures of abundance, biomass and size from 2010 (Ref. 19.249). Data from 15 stations across the flats were gathered in April, July and October 2010 and January 2011. Mean and standard deviation of *M. balthica* abundance, shell and tissue ash-free dry-weight (AFDW), length and juvenile Tellinacea abundance were utilised in a cluster analysis for each season. With this analysis each cluster represents a distinct population 'type' distributed across the flats. The cluster groups were overlaid on a map, **Figure 19.38**, showing the current estimation of the HPB thermal plume extent (calculated from water and sediment temperature sensor measurements taken across Stert Flats during spring and summer 2011; the map has been drawn using night-time temperatures, in order to reduce the influence of naturally-occurring changes in sediment temperature caused by solar irradiance).

19.6.187 Nine sites in the Severn Estuary, including Hinkley Point, were identified as likely habitats for *Macoma*. The sites were visited to identify the occurrence of *Macoma* and, if present, quantify population parameters over the high and/or mid-shore levels (Ref. 19.249). Individual length and age data (obtained by counting growth rings) were then processed for five sites between Hinkley Point, in the south, and Clevedon, in the north (Hinkley Point, Weston-Super-Mare, Kewstoke, Wick-Saint-Lawrence and Clevedon).

19.6.188 The results of this investigation (Ref. 19.249) showed that there was no clear correspondence between *M. balthica* population 'types' (cluster groups) on Stert flats and thermal uplift from HPB for any of the four seasonal surveys undertaken in 2010. The cluster groups did not appear to correspond to the thermal uplift contours. Nor did they clearly correspond to shore level or distance from the River Parrett. Based on this assessment, there was no apparent signal of contemporary thermal impacts on the intertidal *M. balthica* populations in the study area.

19.6.189 This same study (Ref. 19.249) confirmed that *M. balthica* populations are present elsewhere in the Severn Estuary. The presence of the species has been confirmed at each of intertidal sites between Hinkley Point and Clevedon and also further up-river of this point. The data showed that there are significant differences in both size and age between the various sites visited. These data also showed that the *M.balthica* population close to Hinkley Point and the area of influence of the HPB plume did not have the smallest or youngest individuals in the Severn; they show other populations with different or the same size and age characteristics, with the Hinkley Point population being within the measured range of variability and not at one extreme. The presence of other populations in the vicinity of Stert Flats suggests that any potential local thermal plume impacts could be mitigated by recruitment to these flats from elsewhere in the estuary.

19.6.190 The conclusion of these studies is that the current weight of evidence does not support the proposition that the HPB plume is affecting the structure of *M.balthica* populations in Bridgwater Bay.

19.6.191 In considering the impact of HPC alone (with the influence of HPB being the existing baseline), where HPC will contribute thermal inputs over a relatively small spatial extent of Stert Flats, the magnitude of this effect is considered to be low (involving a very low level of change). The moderate sensitivity of this species combined with its high value provides a combined receptor sensitivity and value of medium. The resultant impact associated with HPC would thus be of **minor adverse** significance.

IMPACT: Thermal Plume on Benthic Communities on Stert Flats

19.6.192 Other benthic species that have a significant functional role on Stert Flats, such as the small but highly abundant gastropod *Hydrobia* and the polychaetes *Hediste* and *Nephtys*, are not regarded as particularly temperature sensitive. Aside from being prey to other species, *Macoma* has an additional value within this system as it contributes to the bioturbation of superficial sediments. The other species present, however, also contribute to this processing suggesting that any reduction of *Macoma* in this role would be of little significance. Overall, the ecological functioning of the intertidal area exposed to the HPC plume is expected to be unchanged, with the receptor being of low sensitivity and the effect of low magnitude, and any impact thus of **minor adverse** significance.

IMPACT: Thermal Plume on Subtidal Benthic Habitats

19.6.193 The subtidal soft sediments off Hinkley Point and Stert Flats will experience very little of the thermal plume (see **Figures 19.24** to **19.26**), suggesting a low magnitude effect. The thermal sensitivity assessments (Ref. 19.33) have found all species to have between low and moderate thermal sensitivity, rated overall as low, leading to an impact of **minor adverse** significance.

IMPACT: Thermal Plume on Microphytobenthos

19.6.194 The microphytobenthos that probably contribute the bulk of the primary productivity within this system are predicted to be unaffected by the thermal plume as their photosynthetic optimum typically falls between 20-30°C (Ref. 19.194). As many of the microphytobenthic species are found across coastal waters in most of Europe, a 3°C increase should be within the tolerance of the assemblage and so **no impact** is expected.

IMPACT: Thermal Plume on Crangon Crangon

19.6.195 The shrimp *C. crangon* is the most abundant epifaunal species around Hinkley Point (Ref. 19.33) and is a major food resource for demersal fish and intertidal birds, as well as having a significant influence on the benthic community as it's also a major predator. The wide distribution of this species extends south to the Moroccan coast of Africa and into the Mediterranean. *C. crangon* is considered to have a high tolerance to increased temperature (Refs. 19.33 and 19.193) and thus regarded as very low sensitivity to impact in this instance. In the colder waters of the Wadden Sea, shrimp abundance is higher after mild winters, and laboratory experiments have shown a temperature optimum above 20°C (Ref. 19.193).

19.6.196 The *C.crangon* populations at Hinkley Point show a slight increase in abundance over time, suggesting there is no detrimental effect of the current discharge from

HPB (Ref. 19.102) but perhaps minor benefit. The magnitude of the effect that would be associated with HPC is thus considered to be very low, and the significance of any impact would be **negligible**.

IMPACT: Thermal Plume on Adequacy of Intertidal Invertebrate Prey Resource

19.6.197 Seasonal increases in the population size of *C. crangon* might be expected to increase predation on recently-settled and juvenile *Macoma balthica*, but in practice predation in the May and June period is the most important factor in *M. balthica* spat survival, i.e. the period when the shrimp population has been shown not to be increasing, while seasonal increases in the shrimp population will relate to juveniles too small to exploit *M. balthica* as a prey species.

19.6.198 As waterfowl are primarily a terrestrial/coastal feature, the direct impacts from HPC are dealt with in **Volume 2**, **Chapter 20**, Terrestrial Ecology and Ornithology, of this ES. The indirect effects of food availability on birds as result of the thermal plume are discussed briefly below.

19.6.199 The distribution of *M. balthica* is not uniform, with greater levels of biomass being present on the lower shore. On the mid and upper shores of Stert Flats species such as *Hediste diversicolor*, *Hydrobia ulvae* and *Nephtys hombergii* provide a significant amount of the prey biomass present (see **Figure 12** in Ref. 19.51). Despite these distributional differences in prey composition the distribution of waterbirds does not mirror this pattern (see **Appendix 20B**); this suggests that the individual birds present within the area affected by the thermal plume are more generalist feeders. As *M. balthica* represents between 30% to 90% of the biomass in various areas of Stert Flats, the reduction of up to 11% of this resource, based on HPC + HPB at 100% (i.e. 3.3% to 9.9% of biomass), is relatively small and is unlikely to significantly reduce the prey resource available to the birds present. Given that there is no detectable effect on *M. balthica* due to the current HPB plume (as found above), the real-world effect is also likely to be lower than is predicted by the model.

19.6.200 Provisional outputs of a trophic model (known as the MORPH model) support the conclusions drawn above (Ref. 19.51). Initial runs of this model show that the prey resource available is adequate to support the number and types of birds recorded in the area, as individuals are able to switch to different types of prey as *M. balthica* biomass declines.

19.6.201 The evidence available suggests that potential effects on the survival and/or body condition of birds feeding on the intertidal due to changes in the invertebrate prey resource are unlikely to be discernible. Their sensitivity to the effect is thus considered to be very low and the magnitude of the effect associated with HPC alone would be low. Hence the significance of any impact would be **minor adverse**.

iii. Chemical Discharges

Introduction

19.6.202 During the operational phase a number of non-radiological waste water discharges will be made. These will be primarily due to:

Whilst commissioning (via cross-shore drain and main cooling water outfall)

i conditioning of the cooling water system and other plant; and

ii treated sewage and surface drainage.

Post commissioning (via main cooling water outfall)

iii antifouling measures in the sea water cooling system;

iv effluent from site services (demineralisation plant, laundry etc.);

v treated sewage and site drainage; and

vi hydrazine.

19.6.203 Cooling water will be abstracted from a series of near-seabed intakes some 3.3km offshore. During normal operation, seawater will be abstracted at approximately $65m^3.sec^{-1}$ for each unit and subsequently discharged at the same rate through a pair of outfall head-works, again mounted on the seabed, some 1.8km offshore. The locations of the intake and outfall tunnels are shown in **Figure 19.6**.

19.6.204 Detailed information on non-radioactive discharges during construction, commissioning and operation of HPC is provided in the **Volume 2, Chapter 18** 'Marine Water and Sediment Quality' of this ES.

IMPACT: Corallina and Sabellaria via Commissioning Wastes Discharged via Cross-Shore Discharge

19.6.205 Commissioning waste streams arise as the integrity and function of various areas of plant are tested, or established areas of plant are taken out of storage and the need arises to discharge conditioning volumes. All such discharges are of water, together with solids disturbed by the flow. These tests are classified as 'cold flush' and 'hot flush', with effluents from the latter incorporating ΔT.

19.6.206 Only 'cold-flush' tests will result in effluents being put to the temporary cross-shore discharge route described under 'Construction Impacts' above; 'hot flush' tests will await the availability of the operational cooling water discharge route and associated sea water pumping capacity.

19.6.207 The potentially sensitive receptors to effluents arising via this route due to construction have already been described. There will be an overlap in the use of the cross-shore discharge for both construction and commissioning purposes, as surface water, dewatering water and treated sewage will continue to be discharged via the cross-shore discharge until other means become available.

19.6.208 As with the construction discharges by the same route, management of the various waste streams involved will ensure that all EQS requirements are met at the point of discharge from the sea wall, and that levels of solids are controlled to the median ambient level of $250mg.l^{-1}$.

19.6.209 Given the nature of the biotopes involved (all variable salinity in character) a low sensitivity to this impact and low magnitude result in a predicted impact of **minor**

adverse. Equivalent impacts on the *Corallina* biotope and the *Sabellaria* interest (as described in Appendix 19A) are of **no impact** and **negligible** impact respectively.

IMPACT: Subtidal Habitats via Commissioning wastes discharge

19.6.210 Only once the main cooling water system is complete (cooling water pumps plus associated offshore intake and outfall infrastructure) will hot-flush testing commence, and once that plant is available no further commissioning discharges will be put to the cross-shore discharge route.

19.6.211 The availability of the main cooling water (CW) plant will permit both increased initial dilution of effluents and their discharge offshore, a distance removed from potentially sensitive habitats. As a consequence, in terms of the marine ecological interest, the resultant impact of these discharges will be of low magnitude and involve receptors of low sensitivity, resulting in an impact of **minor adverse** significance.

Operational Waste Streams: Residual biocide

19.6.212 Where the biological fouling of marine cooling water circuits by the planktonic larvae of bivalves and barnacles, or tube-building worms such as *Sabellaria*, and the adult organisms that subsequently develop, presents a risk, a means of control has to be applied by the plant operator. A variety of means of control are available (Refs. 19.196 and 19.198) but principal amongst these is low level chlorination. Under this approach a low level of oxidant, produced either by the electrochlorination of seawater or through the addition of sodium hypochlorite solution, is dosed into the cooling water stream either on a continuous or intermittent basis. An appropriate level of chlorine in the circulating cooling water controls both macrofouling (settlement bivalves and barnacles) and the build up of microfouling (biofilms) (Refs. 19.196 and 19.198).

19.6.213 The preferred option described in the GDA (Refs. 19.246 and 19.247) is therefore to select an approach based on self-cleaning bar screens at the intake and chlorination of the cooling water prior to the condensers if/as required.

19.6.214 The need for dosing is that of exercising control on a precautionary basis so as to retard biological growth within the cooling water circuit. In practice it is unhelpful to apply a lethal dose of a biocide as this will tend to release larger organisms or aggregations of organisms within the cooling water flow, readily resulting in the plant blockage the operator seeks to avoid. As a result, current best practice is to apply a chronic rather than acute toxicant which is effective within the cooling water system itself, but having little or no impact beyond the point of discharge. The use of oxidant chemistry offers an additional advantage in that the base chemistry of seawater exercises a level of demand, significantly compounding the reduction in levels of residual oxidant remaining as the discharged cooling water effluent is dispersed and diluted.

19.6.215 In variance from the GDA it is considered that dosing to $0.5 mg.l^{-1}$ of active chlorine once every 30 minutes per cooling channel will not be required. This is because operational experience at HPA and HPB suggests that the risk of biofouling is likely to be low at HPC. This long term operational experience at the site is thought to be due primarily to the extreme turbidity regime normal to the nearshore waters of Bridgwater Bay as:

- The very high turbidity levels in the waters around the seabed intake will prevent biofouling by algae.
- Flow rates within the cooling system will typically be $2m.s^{-1}$, and in combination with these high turbidity levels this will tend to discourage successful settlement.
- The very high suspended solids levels of the water extracted from Bridgwater Bay and their low available organic carbon content are understood to greatly limit the 'scope for growth' (i.e. a negative energy balance where energy used to filter food from the suspended sediment is greater than that assimilated from the filtered particles) of species such as the common blue mussel *Mytilus*.

19.6.216 Although the likelihood of biofouling is expected to be low at HPC there may be occasions when cooling water flows are reduced, such as during major outages, when organisms will be able to colonise the cooling system more readily. This is less significant at the Forebay but fouling in the water box next to the condenser is potentially serious as it could result in the blockage of condenser tubes. Reef forming *Sabellaria* is very tolerant of high turbidity and extreme disturbance and could therefore become a problem at Hinkley Point.

19.6.217 It is therefore considered important that the HPC site has the ability to chlorinate the cooling system, should this prove to be necessary, albeit not at the levels or frequency described in the GDA. When chlorination is undertaken the dosing will take place prior to the condensers but after the drumscreens, thus avoiding any dosing of the Fish Recovery and Return system (see discussion of this particular need later in this Chapter).

19.6.218 As described above, the GDA for the EPR design identifies that under normal conditions worst case chlorination will involve injecting $0.5mg.l^{-1}$ of active chlorine, applied sequentially once every 30 minutes per cooling channel to achieve a Total Residual Oxidant (TRO) level of $0.2mg.l^{-1}$. This would only be applied when the sea temperature exceeds 10°C. However, in variance from the GDA, under most circumstances at HPC it is expected that chlorination will not be required. The water quality modelling utilised in this ES (see **Volume 2**, **Chapter 18**) is based on the maximum concentration of residual oxidants downstream of the condensers being $0.2mg.l^{-1}$ if both UK EPR units are being dosed and $0.1mg.l^{-1}$ if only one UK EPR unit is being dosed.

19.6.219 The following proven approach will be adopted to minimise the amount of chlorination required:

- A strategy will be implemented based on "Cooling water management in European power stations: Biology and Control of Fouling" and best practice used by EDF Energy Nuclear Generation (formally British Energy) for its existing fleet of nuclear power stations as set out in their strategy document, Ref. 19.245. This involves the maintenance of a site specific risk based protocol to prevent biofouling. This is an important difference from the general approach described in the GDA.

- The strategy described in Ref. 19.245 describes the fouling control hierarchy as involving screening, cleaning and dosing in that order of preference. Effective screening is the first line of defence, so appropriate plant and practices will be put in place at HPC to achieve this. Screening and filtration help prevent systems becoming fouled but eventually the systems will need to be cleaned. Chemical dosing is a means of limiting fouling but is only carried out in conjunction with screening and cleaning and will not be relied on as the sole means of preventing fouling.
- Identifying the need for chlorination will be closely linked to monitoring protocols for fouling, including monitoring of the condenser efficiency, examination of growth in circuits and monitoring populations of organisms on surrounding shores.

19.6.220 The dosing strategy that will be maintained at HPC will be a risk based intermittent dosing regime that will respect both the operational needs of the plant and local environmental sensitivities.

IMPACT: Subtidal Habitats due to Chorine Discharge

19.6.221 Although it is anticipated that chlorination will be required only infrequently at HPC, the ability to chlorinate is regarded by the operator as a necessary precautionary measure. At some point in the life of the station, changed conditions (e.g. brought about gradually via climate change, or more suddenly via tidal barrage construction), chlorination might become necessary, perhaps at short notice. As a result the effects of a chlorinated discharge need to be discussed here.

19.6.222 Whether added as either sodium hypochlorite solution or produced in situ by electro-chlorination of sea water, the chlorine reacts rapidly by oxidation with the bromide (and to a lesser extent ammonia) in sea water to produce a complex mixture of mainly brominated compounds, dominated within the cooling water circuit itself by hypobromous acid, which provide the active disinfectant. Collectively these disinfecting (oxidising) compounds are known as Total Residual Oxidant (TRO), expressed as a chlorine equivalent (Ref. 19.197).

19.6.223 To provide effective antifouling control within the cooling water circuit the standard chlorine dose applied results in a TRO of $0.2 mg.l^{-1}$ at the condensers. The Environmental Quality Standard (EQS) is $0.01 mg.l^{-1}$ TRO requiring dilution or decay of 20x.

19.6.224 To describe the mixing zone that would be associated with HPC, the GETM model was used to predict TRO levels in the receiving water (Ref. 19.60). Simulations were run for an April to May period to represent the most typical time when chlorination might be applied (see **Figure 19.28** and **Figure 19.29**). The results indicate that the area of exceedance of the EQS (standards derived under the requirements of the Dangerous Substances Directive) associated with HPC will not extend to the ecologically sensitive areas of the intertidal habitat (se **Volume 2, Chapter 18**). On the basis of the EQS, the sensitivity of the receptor may be considered to be medium, the magnitude of effect low, and the impact significance **minor adverse**.

IMPACT: Intertidal Habitats due to Chlorine Discharge (Chronic)

19.6.225 To test whether or not the key intertidal species on the Hinkley Point mudflat might vary in their resistance of chronic TRO effects, further studies were carried out. Provisional toxicity testing with three abundant species in that area is summarised in Ref. 19.53. A conservative view of the data arising from this effort suggests the potential for some chronic toxicity to sensitive species, and in particular *Macoma*. A precautionary screening level (SL), considering the potential for sublethal effects of TRO exposure in the form of reduced feeding by *Macoma*, $0.001mg.l^{-1}$ TRO has thus been suggested (see Ref. 19.14). The extent of the mixing zone allied with that SL is shown in **Figure 19.28** and **Figure 19.29**.

19.6.226 Allied predictions of plume extent in relation to habitat type, assuming that both HPB and HPC are chlorinating simultaneously, are provided in **Figure 19.30** and **Figure 19.31**.

19.6.227 On the basis of the suggested SL, and presuming the application of continuous chlorination at both HPB and HPC (noting that such chlorination has not been applied at HPB for many years), the sensitivity of the receptor may be considered to be medium, the magnitude medium, and the significance of the impact **moderate adverse**.

IMPACT: Subtidal Habitats due to Chlorination By-Products Discharge

19.6.228 The acute oxidants formed by chlorination are short lived and are not persistent in natural waters. The residual complexity is the consequent production of numerous more persistent compounds formed by reaction between chlorine (bromine) and other mineral or organic constituents of natural waters. Collectively these compounds are known as chlorination by-products (CBPs) (Refs. 19.198 and 19.199). Given their intimate dependency on local seawater characteristics the actual 'fingerprint' of CBPs produced varies from site to site.

19.6.229 Bromoform is invariably the most common CBP in seawater cooled power station effluents, but other trihalomethanes, haloacetic acids, haloacetonitriles and halophenols are also found (Ref. 19.199). Given that chlorination has not occurred at the Hinkley Point site for many years the likely level of CBP production, and particularly bromoform production (although this will most probably fall into the range already documented for a range of other sites (Ref. 19.200) of $1\text{-}43\mu g.l^{-1}$ at the cooling water outfall itself), is unknown.

19.6.230 Extensive monitoring around existing nuclear power plants whilst confirming the presence of many CBPs, has shown the concentrations of CBPs measured in the cooling water outfalls to be approximately 1,000 times lower than the acute toxicity thresholds known for each. These CBPs are not bio-magnified in the food chain and are not considered a health risk (Ref. 19.200).

19.6.231 On this basis, receptor sensitivity to exposure to the plume can be regarded as low and the magnitude of the effect medium, resulting in an impact of **minor adverse** significance.

IMPACT: Intertidal and Subtidal Habitats due to Hydrazine Discharge

19.6.232 The potential use of hydrazine and the extent of any chemical plume is described in **Volume 2, Chapter 18**.

19.6.233 GETM modelling at HPC (Ref. 19.60) shows that the acute PNEC is exceeded at the surface in the immediate vicinity of the discharge and the chronic PNEC is exceeded also in the surface water (only), due to the thermal buoyancy of the plume, up to 2km from the discharge. **Figure 19.32** illustrates the extent of intersection with the bed.

19.6.234 The annual mean hydrazine concentrations are not predicted to exceed the chronic PNEC across any areas of the intertidal, so **no impact** is expected on this receptor.

19.6.235 The chronic PNEC will be exceeded for a small subtidal area around the outfall structures themselves. The sensitivity of the subtidal biotopes is considered to be low and the magnitude of impact also low, suggesting an impact of **minor adverse** significance. Further details are provided in **Volume 2**, **Chapter 18**.

IMPACT: Subtidal Habitats due to Ammonia Discharge

19.6.236 Ammonia exists as an equilibrium between free ammonia and ionised ammonium hydroxide: NH_3 + H_20 ⇆ NH_4+ +OH^{-}. The equilibrium is altered by changes in temperature, pH and salinity. Free (unionised) ammonia is the toxic form, so changes in general water quality as well as total ammonia concentration will affect the potential toxicity of the discharge.

19.6.237 The EQS for unionised ammonia is 21µg.l^{-1} NH_3-N.

19.6.238 With current water quality conditions and using the plume as a guide to mixing area (20m deep, 10km wide 20km long), and assuming no decay after discharge, the annual HPC Nitrogen discharge would lead to an average uplift in unionised ammonia levels in the plume of about 2.5µg.l^{-1}. This would be less than 1% of the background level of 360µg. l^{-1} (95th percentile) and so the magnitude is considered to be very low. The sensitivity of the receptor is low given the baseline conditions and the impact on marine ecological receptors is considered to be **negligible**.

iv. Impingement of Fish and Shrimp

19.6.239 The routine abstraction of approximately 125$m^3.s^{-1}$ of cooling water from the Bridgwater bay area of the Inner Bristol Channel for the proposed HPC will carry with it the risk of fish impingement and entrainment resulting in the loss of fish from estuarine populations. Although the cooling water intakes will be protected by coarse bar screens at their entrance to prevent the intake of larger fish and debris, a significant number of organisms (fish and crustaceans, and plankton) will inevitably enter with the cooling water.

19.6.240 Owing to their high relative abundance within local inshore waters and their relative lack of mobility in comparison to adults, the majority of fish abstracted by power station intakes are the egg, larval and juvenile lifestages.

19.6.241 The larger of these organisms (fish and crustaceans >25mm length) will be impinged and removed by fine-meshed drum-screens (currently 10mm at HPB, but 5mm for HPC), before the cooling water enters the power station cooling system, in order to prevent them blocking the condenser tubes.

19.6.242 The smaller organisms (mostly the eggs and larvae of fish and crustaceans) that pass through the drum screens will be entrained in the cooling flow and continue on through the power station cooling system to be returned via the thermal discharge back to the Bristol Channel. As noted below, significant proportions of these entrained organisms are expected to survive the entrainment process to re-enter the estuarine ecosystem.

19.6.243 A small proportion of the incoming cooling water ($12m^3.s^{-1}$ across both EPR units out of the total of around $125m^3.s^{-1}$ maximum) is filtered via separate band-screens sited adjacent to the main drum screens, supplying essential cooling supplies for auxiliary and back-up systems. This has a low duty and minimal impact compared with the main cooling water circuit and therefore, is not discussed further.

19.6.244 Comparison of data from the fish trawling sites surveyed during 2008 to 2009 suggests that, when taking the full catch across surveys as a whole, there was little difference in terms of the fish catch between offshore and nearshore zones (Ref. 19.202). Thus, impingement records from HPB provide a satisfactory basis for predicting abstraction effects for HPC. Entrainment data from HPB are sparser and plankton surveys indicate more variability between nearshore and offshore areas (Ref. 19.33), therefore HPB is not a good model and the studies supporting this ES have thus estimated impingement effects from plankton survey data alone.

19.6.245 Ref. 19.202, together with Refs 19.27 and 19.43, summarise and assess abstraction effects data from HPB and predict impingement and entrainment rates for HPC without and with proposed abstraction mitigation measures. The means of mitigation and the consequential residual impacts are discussed later in this chapter of the ES; the discussion that follows here is constrained to a consideration of unmitigated impacts.

19.6.246 Impingement predictions for HPC are based primarily on a Comprehensive Impingement Monitoring Programme (CIMP) carried out over 12 months from February 2009 to February 2010 (Ref. 19.36) and ichthyoplankton surveys off the Hinkley Point area undertaken quarterly in 2008 and again in May 2009 (Ref. 19.33). Where suitable and appropriate biological data are available, these predictions are put into the context of local commercial landings and local fish populations (spawning-stock biomass (SSB)).

Assessment of Impingement Loss (without mitigation)

19.6.247 CIMP surveys carried out during 2009 and 2010, and analyses of raw impingement catch data, followed best practice procedures set out in Ref. 19.9. This requires a sampling intensity of at least forty 24 hour impingement samples per year, collected according to a strict protocol.

19.6.248 The assessment work undertaken and detailed below has been based upon the following assumptions for an unmitigated abstraction design:

- intake design similar to HPB;
- no chlorination at the intake, within the intake tunnels;
- continual low dose chlorination into the cooling water flow from the pumping station onwards;
- 5mm drum-screen mesh; and
- no FRR system.

19.6.249 Estuarine waters contain a high proportion of juvenile fish, and around 90% of the impingement catch at HPB comprises fish of <20cm total length. Although mostly of no direct value to commercial fisheries, these individuals are important features of the populations both in terms of the protected status of some species and the subsequent potential contribution of all species to the adult fish assemblage. Egg, larval and juvenile lifestages do, however, exhibit high natural mortality rates and relatively few of the individuals lost as a result of impingement and entrainment would have been be likely to survive through to adulthood. To give an indication of the relative value of juvenile life stages to the adult population, the authors of Ref. 19.203 and 19.204 developed a measure known as 'equivalent adult value' (EAV), defined as "*the fraction of the adult lifetime fecundity of an adult that has just reached maturity which is required to replace that juvenile*" (Ref. 19.205). On this basis the author of Ref. 19.206 developed this technique for application within the assessment of power station impact assessment. This approach is further explained in Ref. 19.207, where the authors applied the method for the analysis of Sizewell power station impingement data.

19.6.250 There are a number of limitations associated with the use of EAV. Their calculation is based on the development of life-tables containing detailed information on life-history data, such as age-specific mortality, fecundity and growth rates, which are not available for all species or geographic stocks. Also, the EAV method does not take into account density-dependent factors in population dynamics. It is generally accepted, therefore, that the EAV method represents a worst-case in terms of likely lost production.

19.6.251 The predicted impingement losses for HPC described in Ref. 19.43 are scaled from recent HPB screen surveys. Predictions in this report are primarily based on the BEEMS Comprehensive Impingement Monitoring Programme (CIMP) carried out over 12 months from February 2009 to February 2010 (Ref. 19.36). For a few species, where suitable and appropriate biological data are available, these predictions have been put into the context of local commercial landings and local fish populations (spawning-stock biomass, SSB).

19.6.252 Predicted impingement rates for HPC do not take account of the difference in screen mesh size, which will be 5mm on HPC compared with 10mm on HPB. The HPC screens will therefore retain some smaller fish that would have been entrained into the cooling water system at HPB. There is no reliable method of accounting for this difference. Impingement estimates for HPC will therefore be underestimated, and entrainment rates overestimated.

19.6.253 Data from CIMP were available for up to 64 species of fish and up to 14 species of crustacean. For many of these species the predicted impingement is based upon very small numbers of individuals caught on the screens of existing power stations during limited (40 x 24 hr) sampling intervals at an abstraction rate of $30m^3.s^{-1}$. The predicted impingement has been calculated by scaling the numbers up to a full year at the proposed cooling water abstraction rate of $125m^3.s^{-1}$. For example, only two Allis shad *(Alosa alosa)* were caught, but after scaling up, this leads to a predicted impingement of 68 individuals per year. Such impingement predictions for species caught infrequently are subject to more uncertainty.

19.6.254 For some species of commercial and/or conservation importance, sufficient data are available to make an assessment of stock data and the impact of predicted impingement on the local fish populations in the Bristol Channel and Severn Estuary areas. **Table 19.26** lists the 15 species that constitute about 88% (by number) of the total numbers of fish and shrimp impinged at HPB, providing a prediction of the HPC catch without mitigation. **Table 19.27** shows predicted HPC catch in the context of spawning stock biomass (SSB) or stock size (numbers), as appropriate.

Table 19.26: Predicted Total Annual Impingement (numbers of fish as, EAV, and total number of shrimp) of Key Species at HPC and HPB for Selected Species for an Abstraction Rate of $125m^3.s^{-1}$ via HPB-type Intake Structures, Without Mitigation (Data from Ref. 19.43)

Species: Common Name	EAV Annual Impingement at HPC, Current (HPB) Intake Design	EAV Annual Impingement at HPB
Sprat (largest numbers)	3,380,850	936,386
Whiting (BAP)	288,078	79,253
Sole (BAP)	32,429	8,599
Cod (BAP)	32,063	8,733
Herring (BAP)	44,792	12,570
Plaice (BAP)	493	129
Blue whiting (BAP)	160	46
Eel (Eel management plan)	1,304	351
Twaite shad (SAC designated)	2,276	646
Allis shad (SAC designated)	68	22
Sea lamprey (SAC designated)	207	42
River lamprey (SAC designated)	82	18
Salmon (SAC designated)	0	0
Sea trout (SAC designated)	0	0
Brown shrimp (*Crangon crangon)* – the main crustacean impinged	Estimated annual impingement (no.) 19,135,756	Estimated annual impingement (no.) 4,911,592

Commercial Species

19.6.255 **Table 19.26** shows impingement rates for key, commercial fish species recorded at HPB and rescaled values for HPC, calculated as Equivalent Adult values (EAVs). The rescaled numbers assume replication of the HPB intake design, with no mitigations. Impingement rates of individual species are considered below in the context of known stock data (Ref. 19.43).

19.6.256 **Figure 19.33** shows the distribution of the ICES statistical rectangles referred to in the analysis that follows.

IMPACT: Sprat due to Impingement

19.6.257 Until recently there has been little information on sprat in the Bristol Channel. From 2003, regular biannual Environment Agency (unpublished data) multi-method surveys in the Estuary above Weston-super-Mare have shown sprat nurseries off Cardiff and Penarth.

19.6.258 It seems likely that the sprat encountered at Hinkley Point are part of a population that is limited to the Bristol Channel and, given the lack of any assessment for the species, it is considered that the most useful comparison for sprat is between impingement data at Hinkley Point power station and landings data reported for UK vessels fishing in the Bristol Channel; ICES statistical rectangles (see **Figure 19.33**) 32 E5–E7, 31 E5–E7 and 30 E5 (sprat = 190kg).

19.6.259 Based on the scaled-up CIMP dataset, the total annual estimated impingement of sprat at HPC, assuming a constant abstraction rate of $125m^3.s^{-1}$, would be about 3.38 million fish. Owing to a lack of biological and population data, it is not possible to derive an EAV for sprat, but, as adult sprat are comparatively small, an Equivalent Adult Value of unity is assumed, although this is likely to be a conservative assumption. With the current cooling water intake design, the Equivalent Adult numbers of sprat likely to be impinged annually at HPC without mitigation is approximately 26.4t.

Table 19.27: Equivalent Adult Value (EAV) of Predicted Annual Fish Impingement at Hinkley Point C Power Station at Maximum Cooling Water Demand of $125m^3.s^{-1}$, Without Mitigation

Species	Estimated Annual Impingement at HPC (no. of fish)	EAV Annual Impingement at HPC (no. of fish)	EAV Annual Impingement at HPC (biomass - t)	Est. local spawning stock biomass (2004-8) (biomass - t)	EAV Annual Impingement at HPC (% local SSB)	Local Annual Landings (t)	EAV Annual Impingement (% Local Annual Landings)	Impact Assessment (without mitigation)
Sprat	3,380,000	3,380,000	26.40			0.19	13,894.0	Moderate
Whiting	2,100,000	288,078	51.28	1,613.00	3.18	33.48	153.0	Moderate
Sole	602,776	32,429	7.43			263.00	2.8	Minor
Cod****	371,097	32,063	140.40	975.00	14.40	65.17	215.0	Moderate
Herring	90,526	44,792	5.64			119.40	4.7	Moderate
Plaice	5,383	493	0.23	952.00	0.02	84.00	0.3	Minor
Blue whiting	1,166	160	0.02	*37,900.00	5.28×10^{-5}			Minor
Sea bass								Minor
Twaite shad	2,276				Approx. 1.24% local pop.			Moderate
Eel	1,304		0.08	133.40	0.06	26.00	0.3	Moderate
River lamprey	82				<0.07% pop.			Moderate
Sea lamprey	207				1.36% pop.			Moderate
Salmon	0			**58.62 million eggs (Min spawning stock level)		***2482 fish (comm/ recr angling)		Negligible

Notes: *Figures are given as a percentage of spawning stock biomass (SSB) and local annual landings (data from Ref. 19.43). The impact levels are as discussed in the text. SSB is a mean estimate for years 2004 to 2008, inclusive. Local annual landings refer to data from vessels fishing in the Bristol Channel, using ICES statistical rectangles. Based on the scaled-up CIMP dataset.*

* *Combined stock in ICES Subareas VIII and IX and Divisions VII d-k (the "southern areas")*

** *Conservation limit for the Rivers Severn, Wye and Usk combined.*

*** *Mean annual catch (2004-08) in the Severn Estuary net fishery combined with rod catches on the Rivers Severn, Wye and Usk (whether returned to the water or not).*

**** *Cod assessment has subsequently reappraised to account for bias caused by an exceptional spike in recruitment during the period of sampling upon which this assessment was based, in 2009; the ratio of annual catches 2008:2009 was 5.8% and that for the mean of 2004-2008:2009 was 7.3% (Ref. 19.260).*

19.6.260 As the catch of sprat in the local fishery is small (0.19t currently, not as a targeted fishery but incidental), this impingement is almost 140 times that of the local fishery. As no stock assessment is made for sprat, it is not possible to assess the impact of impingement on local populations.

19.6.261 Given that little information is available on the sprat population, a precautionary assessment suggests an impact of **moderate adverse** significance, based on medium magnitude and medium value.

IMPACT: Whiting due to Impingement

19.6.262 Although the basic biology of whiting is well known, it has proved difficult to estimate its abundance and to follow the dynamics of the different populations around the UK (Ref. 19.43). Part of the problem may be related to distribution and stock structure, and the extent of mixing between areas. However, it is well established that there has been an overall decline in abundance of whiting to very low levels in many areas (Ref. 19.209).

19.6.263 There have been sufficient uncertainties in the data used in exploratory assessments for the Celtic Sea whiting (Divisions VIIe–k) stock that ICES is currently unable to provide estimates of fishing mortality or SSB, although SSB shows a decreasing trend and recent recruitment is low (note that survey results indicate that the 2007 year- class may be stronger than the recent average).

19.6.264 The Environment Agency (unpublished data) has shown whiting nurseries to be present on both the English and Welsh coasts of the Bristol Channel and Severn Estuary. It seems likely that the whiting encountered at Hinkley Point are part of a population that occupies the Bristol Channel and Celtic Sea, with some limited mixing with whiting in the Irish Sea. The most useful comparison is between impingement data at Hinkley Point and landings data reported for UK vessels fishing in ICES statistical rectangles (**Figure 19.33**) 32 E5–E7, 31 E5–E7 and 30 E5 (= 33.48t, mean 2004–08). At a population level, an indicative comparison is with the SSB estimate for Divisions VIIe–k, weighted by the ratio of the above landings to total UK landings for VIIe-k. The average UK landings from this stock from 2004 to 2008 were 529t, and the average annual SSB is estimated at 25,492t (corresponding to international landings of 9,240t, as estimated by ICES). Therefore, the estimated "local" SSB = 25492 x (33.48/529) = 1613 t.

19.6.265 Based on the scaled-up CIMP dataset, the total annual estimated impingement of whiting at a new power station at HPC, assuming a constant abstraction rate of 125m^3s^{-1}, would be about 2.1 million fish. Using the relationship between total numbers, EAV numbers and EAV weights provided by the Expert System PISCES 2009 to re-scale the impingement estimates derived from the CIMP data, and with the current cooling water intake design, the Equivalent Adult number of whiting predicted to be impinged annually at HPC without mitigation is 288,078 fish (51.28t). This equates to approximately 153% of the local whiting fishery (33.5t) and 3% of the "local" SSB (1613t).

19.6.266 On this basis, without mitigation, a **moderate adverse** impact is predicted, based upon medium magnitude and medium value.

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IMPACT: Sole due to Impingement

19.6.267 Sole stocks have shown substantial variations in abundance over the past 50 years, largely as a result of fishing and variability in breeding success (Ref. 19.210). In the more northern regions, the abundance of sole also fluctuates naturally as a result of severe mortality during very cold winters, such as in 1963. The Environment Agency (unpublished data) has shown sole nurseries to be present on the English coast off Clevedon and the Welsh coast off Peterstone, extending up the M48 crossing. The analytical age-based assessment for the sole stock in the Bristol Channel and Celtic Sea (Divisions VIIf and VIIg, **Figure 19.33**) is based on landings, two commercial catch per unit effort (CPUE) series and one survey index. There is also a confirmatory short UK Fisheries – Science Partnership time-series for this and an adjacent area available to the authors of this assessment. The general trends in the estimates of stock numbers, fishing mortality and recruitment have been similar in recent assessments. The stock is currently considered by ICES to be fished sustainably and to have full reproductive capacity (Ref. 19.209). SSB in 2008 (2200t) is estimated to be above the precautionary biomass limit set by ICES to protect fish stocks. The average (2003–2007) total annual international catch in VIIf, g (not including discarding) was 1,114 t; UK landings were 263 t; and the SSB estimate was 3,240 t.

19.6.268 The sole at Hinkley Point are part of a population that occupies the Bristol Channel and Celtic Sea, with relatively limited mixing with adjacent sole populations. The most valid comparison for sole is between impingement data for the Hinkley Point and landings data reported for UK vessels fishing in the Bristol Channel and Celtic Sea (Divisions VIIf and VIIg), and with the SSB estimate for this stock. Comparison with a more locally restricted fishery or population, in ICES statistical rectangles 32 E5–E7, 31 E5–E7 and 30 E5, say, would ignore the extensive mixing of early life-stages of sole throughout the Bristol Channel and Eastern Celtic Sea.

19.6.269 Based on the scaled-up CIMP dataset, the total annual estimated impingement of sole at a new power station at HPC, assuming a constant abstraction rate of $125m^3.s^{-1}$, would be 602,776 fish (Appendices B2 and B3). Using the relationship between total numbers, EAV numbers and EAV weights provided by the Expert System PISCES 2009 (Ref. 19.43) to re-scale the impingement estimates derived from the CIMP data, and with the current cooling water intake design, the Equivalent Adult numbers of sole likely to be impinged annually at HPC without mitigation is 32,429 fish (7.43t). This equates to approximately 3% of the local sole fishery (263t) and 0.23% of the VIIf,g SSB (3,240t).

19.6.270 On this basis, without mitigation, a **minor adverse** impact is predicted, based on medium magnitude and low value.

IMPACT: Cod due to Impingement

19.6.271 The assessment for cod in ICES Divisions VIIe–k (Western English Channel, Celtic Sea and Bristol Channel) is based on commercial landings, three surveys and four commercial CPUE series. Discard data are not included in the assessment, although a correction for high-grading for the years 2003 to 2005 in the French fisheries has been made. The main uncertainties in this assessment are partial information available on recent quota-induced changes in discarding, and under-reporting and area misreporting of landings. The results of the 2008 assessment are broadly consistent with those of 2007 in terms of trends in fishing mortality, SSB and recruitment, although there was a change in the perception through an upward revision via the fisheries assessment process of the 2005 and 2006 year- classes by 74% and 67%, respectively, and an upward revision of SSB in 2007 by 14%.

19.6.272 Ref. 19.209 considers cod in Divisions VIIe–k (**Figure 19.33**) to be overfished, but currently harvested sustainably. The stock has had a truncated age structure over several decades, and its dynamics have been strongly recruitment-driven, i.e. the stock increased in the past in response to good recruitment and decreased rapidly during times of poor recruitment. Fishing mortality has been very high since the mid-1980s, but has declined since 2002 and is now below the precautionary level of fish mortality set by ICES to protect fish stocks at Fpa (0.68). SSB has been below the absolute biomass limit (beyond which, there are considered too few spawning adults for the population to recover) set by ICES, Blim (6,300t) since 2004, but most recently was estimated to be slightly above the limit. Recruitment since 2002 has been well below the long-term average. The average (2003 to 2007) total annual international catch in VIIe–k (including a high-grading estimate) was 4,175t; UK landings were 343t; and the estimated SSB was 5,133t.

19.6.273 The thermal tolerance of cod is not well known, but scientific evidence (Ref. 19.248) points to the species being cold-adapted, i.e. it prefers lower sea temperatures to warmer ones, especially during its spawning season. Indeed, the Celtic Sea stock management unit of cod lies at the southern limit of the known distribution of cod in the North Atlantic and environs. Very recent data on cod (from eight of the stocks in the NE Atlantic) tracked with electronic data-storage tags (Ref. 19.251) indicate that climate warming will mainly affect cod populations at their early life-history stages and also the prey species on which cod depend, but that cod can exist in a thermal range of -1.5 to 19℃ (a much narrower 1-8℃ in their spawning season). Such ranges would mark cod down as remarkably thermo-tolerant, but the results of other analyses, despite high levels of uncertainty in the basic data, suggest that some of the southern cod stocks might well disappear within the current century if general predictions of climate warming translate to reality. Ref. 252, for instance, evaluated the likely response of all known and managed cod stocks to climate change (warming) in the period up to 2100 and, although it stresses that oceanographic variables other than temperature (e.g. plankton production, prey and predator fields, and industrial fishing) will play a role in future trends of the cod stocks, its prognoses for the southern stocks of cod such as the Celtic Sea stock are not positive.

19.6.274 Ref. 19.43 states that the cod found at Hinkley Point are part of a population that occupies the Bristol Channel and the eastern Celtic Sea and that has limited mixing with adjacent cod populations. The international stock assessment for cod in this region is for ICES divisions VIIe-k (Western Channel, Celtic Sea and Bristol Channel) and therefore includes cod in the western English Channel and Irish coastal waters, which are thought by some scientists to comprise largely separate stocks from those in the Bristol Channel and eastern Celtic Sea.

19.6.275 The international annual catch estimate for cod in ICES Areas VIIe-k was an average of the 2003-2007 data of 4175t, of which the UK's share was 343t, compared with an

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estimated VIIe-k spawning stock biomass (SSB, i.e. mature fish, not the sizes being impinged at Hinkley Point) of 5133 t for the same period.

19.6.276 The ‘local’ UK catch in 2004-2008 was 65.2t (‘local’ being as recorded from rectangles 32E4-E7, 31E4-E7, 30E4-E5, and 29E4, i.e. from Fishguard in the north to the entrance to the English Channel in the south, and west to west of both Lands End and the western landfall of Wales). The ‘local’ catch takes place well outside the Bridgwater Bay area, which functions as a nursery for 0-group fish that will not join the adult stock until they much older.

19.6.277 Ref. 19.43 assumed that the stock in the local area could be approximated by the ratio of the UK catches in the local area to the whole VIIe-k area i.e. the “local” SSB would be of the order of 5133*65.2/343t or 975t. Without independent stock assessments of the various areas independently, this is the considered best assumption that can be made.

19.6.278 The SSB estimate was based on analyses back-calculated from catches and survey data up to 2010, but the same data already show that there was a major recruitment spike of the 2009 cod year class (spawned February-April 2009), already possibly seen as being the second highest recruitment in that stock of cod in the historical time-series (Ref. 19.260). The long term time-series maintained at HPB tends over the years to mirror the spikes in cod recruitment observed through fisheries management studies fairly well, and the CIMP data for 2009/10 (Ref. 19.36, which includes an analysis of length frequencies) clearly show those juvenile cod being impinged in large numbers at that time. It is inappropriate to base future impingement prediction likelihood on data collected solely at the time of this clear spike (Ref. 19.260). A revised SSB reflecting the impact of the 2009 recruitment on the overall Celtic Sea cod stock would not be viewed as scientifically sound until those cod started to appear in the commercial catches in large numbers, which will not be until 2012. Prior to 2009 the last cod recruitment spike in both the long term HPB data and the national fisheries database was in 2000, but the total cod numbers impinged in that (also good recruitment) year were only 37% of those in 2009.

19.6.279 In order to use datasets that are synchronous in time with the catch and stock assessment data, this assessment should ideally be using either 2008 or earlier impingement data or an average for the period 2004-2008 to predict future HPC impingement of juvenile cod. On the basis of monthly time-series of cod numbers impinged at HPB for the periods January 2003 to March 2010, the ratio of annual catches is as follows:

- 2008:2009 : 5.8% of 2009 catch;
- Mean 2004-2008:2009 : 7.3%.

19.6.280 Taking the worst case figure of 7.3%, the HPB and HPC catches are reduced to:

- HPB: 0.29% of local SSB;
- HPC: 0.24% of local SSB;
- HPB+HPC: 0.51% of local SSB.

19.6.281 On this basis, without mitigation, a **minor adverse** impact is predicted based upon low magnitude and the medium value of the receptor.

IMPACT: Herring due to Impingement

19.6.282 Except where a fishery exploits spawning herring (e.g. at Llangwm in Milford Haven), larval surveys are the main tool to locate and assess inshore spawning populations, but insufficient numbers of small larvae have been found to assess the status of these small spawning groups of herring. Only MMO landings statistics from local fisheries are available.

19.6.283 It seems likely that the herring encountered at Hinkley Point are part of a population (or populations) that is limited to the Bristol Channel and adjacent inshore waters and, given the lack of any assessment, it is considered that the most useful comparison is between impingement data for the Hinkley Point and herring landings data reported for UK vessels fishing in ICES statistical rectangles (**Figure 19.33**) 32 E5–E7, 31 E5–E7 and 30 E4–E5 (119.4t, mean for 2004 to 2008).

19.6.284 Based on the scaled-up CIMP dataset, the total annual estimated impingement of herring at HPC, assuming a constant abstraction rate of $125m^3.s^{-1}$, without mitigation, would be about 90,526 fish. Using the relationship between total numbers, EAV numbers and EAV weights provided by Expert System PISCES 2009 to re-scale the impingement estimates derived from the CIMP data, and with the current cooling water intake design, the Equivalent Adult number of herring likely to be impinged annually at Hinkley C is 44,792 fish (5.64t). This equates to approximately 5% of the local herring fishery (119.4t). As no stock assessment is carried out for herring in the area, it is not possible to assess the impact of impingement on local populations.

19.6.285 On this basis, without mitigation, a **moderate adverse** impact is predicted based upon medium magnitude and medium value.

IMPACT: Plaice due to Impingement

19.6.286 Ref. 19.209 advises that the plaice stock in the Celtic Sea (Divisions VIIf,g) had reduced reproductive capacity and was overfished. SSB peaked in the period 1988 to 1990, following a series of good year- classes, then declined rapidly and, since 2002, has been below or around the biomass limit (1,100t). There have been some very weak year- classes since the late 1990s. The average (2003 to 2007) total annual international catch in VIIf,g (not including discarding) (**Figure 19.33**) was 461t; UK landings were 84t; and the SSB estimate was 952t.

19.6.287 Plaice encountered at Hinkley Point are part of a population that occupies the Bristol Channel and Celtic Sea, with some limited mixing with plaice in the Irish Sea. The Environment Agency (unpublished data) has shown plaice nurseries to be present off Cardiff Flats. However, given that ICES conducts separate assessments for 'stocks' in VIIf,g and VIIa (Irish Sea), Ref. 19.43 considers that the most useful comparison for plaice is between impingement data for the Hinkley Point and landings data reported for UK vessels fishing in the Bristol Channel and Celtic Sea (Divisions VIIf and VIIg), and with the SSB estimate for this stock. Comparison with a more locally restricted fishery or population, in ICES statistical rectangles 32 E5–E7, 31 E5–E7

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and 30 E5, say, would ignore the extensive mixing of plaice life stages throughout the Bristol Channel and Eastern Celtic Sea, and with adjacent plaice populations.

19.6.288 Based on the scaled-up CIMP dataset, the total annual estimated impingement of plaice at HPC, assuming a constant abstraction rate of $125m^3.s^{-1}$, would be about 5,383 fish (Appendices B2 and B3). Using the relationship between total numbers, EAV numbers and EAV weights provided by the Expert System PISCES 2009 to re-scale the impingement estimates derived from the CIMP data, and with the current cooling water intake design, the Equivalent Adult numbers of plaice likely to be impinged annually at HPC without mitigation is 493 fish (0.23t). This equates to approximately 0.3% of the local plaice fishery (84t) and 0.02% of the Celtic Sea SSB (952t).

19.6.289 On this basis, without mitigation, a **minor adverse** impact is predicted, based upon a medium magnitude of effect and low value.

IMPACT: Blue Whiting due to Impingement

19.6.290 The ICES assessment of the stock status of blue whiting is based on an analysis of catch-at-age data from commercial fisheries from 1981 to 2009, and three acoustic surveys that between them cover the distributional area of the spawning stock (Ref. 19.43). These show that recruitment of the 2005 to 2009 year classes has been low (following ten years of above average recruitment) and there has been a significant decrease in SSB since 2004, although the estimated abundances for recent years have changed greatly with successive annual assessments. For example, the SSB estimate for 2009 is estimated in 2010 to be about 42% lower than the estimate made in 2009. The Ref. 19.43 assessment values (which have built on previous work) are used here.

19.6.291 There is no evidence that blue whiting in the Bristol Channel and Celtic Sea are discrete from the population that occupies the whole of the west coast of North-West Europe (including the Norwegian Sea), which ICES treats as a single stock for assessment purposes. It is considered that the most useful comparison is between impingement data at Hinkley Point and landings data reported for all vessels fishing the combined stock in Subareas VIII and IX, and Divisions VIId-k (the " southern areas") (= 37,900t, mean 2004 to 2008). At a population level, the mean SSB estimate for the whole stock in the years 2004 to 2008 was 5,360,000t, which is near the long-term mean for the stock.

19.6.292 Based on the scaled-up CIMP dataset, the total annual estimated impingement of blue whiting at HPC, assuming a constant abstraction rate of $125m^3.s^{-1}$, without mitigation, would be about 1,166 fish. Using the relationship between total numbers, EAV numbers and EAV weights for whiting (which we have assumed will be similar for blue whiting) provided by the Expert System PISCES 2009 to re-scale the impingement estimates derived from the CIMP data, and with the current cooling water intake design, the Equivalent Adult numbers of blue whiting likely to be impinged annually at HPC is 160 fish (0.02t). This equates to <0.1% of the blue whiting fishery (37,900t) and <0.1% of the corresponding SSB (5,360,000t).

19.6.293 On this basis, without mitigation, a **minor adverse** impact is predicted based upon medium magnitude and a low value.

IMPACT: Sea Bass due to Impingement

19.6.294 Environment Agency (unpublished data) surveys have shown sea bass nurseries extending from Cardiff Flats eastwards to Arlingham, near Gloucester. However, few sea bass are taken on the HPB screens.

19.6.295 On the basis that the magnitude of impact is very low and a receptor of medium value, the significance of any impact is considered to be **minor adverse**.

IMPACT: Crustacean (including C. crangon) due to Impingement

19.6.296 The coastal areas (out to six nautical miles) off the North Devon coast and off the South Wales coast west of the River Rhymney come under the jurisdiction of the Devon and the South Wales Sea Fisheries Committees (SFC), respectively. The sea area of the Bristol Channel east of the Devon and Somerset border around to the mouth of the River Rhymney in South Wales falls outside the geographic boundaries covered by any SFC and, consequently, is an area where fishing activity remains largely unknown. It is suspected that there may be some artisanal crustacean fisheries, for example stake-netting or push-netting for brown shrimps, because healthy populations are known to exist, but the absence of any fisheries authority in the area suggests that it is of relatively little importance from a fisheries perspective. The South Wales SFC suggests that there is little or no potting activity east of Porthcawl on the Welsh coast, and Devon SFC is similarly unaware of any significant potting or trawling activity east of its border.

19.6.297 The official reported landings of shellfish, as recorded by the MMO (Ref. 19.27), show no brown or pink shrimps from this area in recent years (from 2000). The same data since 2005 show that reported annual landings of brown crab from the Bristol Channel area (as defined by ICES rectangles 30E5, 31E5–E7 and 32E5, **Figure 19.33**) are typically of the order of 200t, but less than 11t (in 2007) was taken in rectangle 31E6, the eastern portion of which is in the area adjacent to the Somerset coast and in the vicinity of Hinkley Point. The level of spatial resolution described by an ICES rectangle prevents us from specifying whether these crabs were taken close to the power station or, more likely, in the extreme west of the area off the North Devon coast. Reported annual landings of velvet swimming crabs *(Necora puber)* and common prawns from the Bristol Channel as a whole since 2005 are 3.5t and <200kg respectively, with just 30kg of velvet swimming crabs (in 2009 only), and no common prawns coming from rectangle 31E6. Most of the landings of these crustaceans in the Bristol Channel area are made into Devon and Cornwall, or to Welsh ports on the Pembrokeshire coast. A population estimate for the brown shrimp and the adjacent Stolford mudflats ($20km^2$) in the 1980s (Ref. 19.100) put the stock level at between $3x10^6$ to $5x10^7$ individuals (approximately 3-50t biomass).

19.6.298 In a national context, the reported landings of these crustaceans into England and Wales in 2008 were: brown crabs, 11,403t; velvet swimming crabs, 332t; common prawns, 33t; brown shrimps, 861t; shore crabs, 21t; and pink shrimps, 13t.

19.6.299 The annual shrimp *(C. crangon)* catch for HPC is predicted to be 19,135,756 individuals (**Table 19.26**), equivalent to around 19t.

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19.6.300 On this basis, without mitigation, a **moderate adverse** impact is predicted based upon medium magnitude and medium value.

Specifically Designated Conservation Species

IMPACT: Salmon due to Impingement

19.6.301 Although estimates of the upstream run of adult salmon are obtained using electronic fish counters or upstream traps on a number of catchments in England and Wales, there are no such data available for rivers entering the Severn Estuary. However, estimates of spawning escapement (numbers of spawning adult fish) are obtained from catch data and exploitation rates, and these are used to assess individual river stock status against conservation limits (CLs: the minimum spawning stock level below which further reductions in spawning numbers are likely to result in significant reductions in the number of juvenile fish produced in the next generation). The CL for each river is defined in terms of eggs deposited.

19.6.302 The River Severn CL is 12.85 million eggs, and the egg deposition estimated for 2008 was 16.56 million, 120% of the CL (mean 131%, 2004 to 2008). The River Wye CL is 35.66 million eggs, and the egg deposition estimated for 2008 was 22.58 million, 63% of the CL (mean 61%, 2004 to 2008). The River Usk CL is 10.11 million eggs, and the egg deposition estimated for 2008 was 21.36 million, 211% of the CL (mean 189%, 2004 to 2008). From these values we can estimate the number of smolts produced, using average egg-to-smolt survival data.

19.6.303 The mean annual catch (2004 to 2008) of salmon from the Severn Estuary net fishery was 837 fish (the long-term average is approximately 3,000 fish), with rods taking an average of 336, 682 and 987 fish from the Rivers Severn, Wye and Usk, respectively.

19.6.304 For the purposes of evaluating the impact of impingement of salmon smolts or adult fish on the intakes at Hinkley Point, data on catches or estimates of abundance for the Severn Estuary and its major rivers, the Severn, Wye and Usk, cover the overwhelming majority of salmon that might be vulnerable. Over the five-year period of 2004 to 2008, the mean annual catch of salmon from the commercial net fishery in the Severn Estuary was 837 fish, and recreational anglers caught an annual average of 2005 salmon from the Rivers Severn, Wye and Usk combined. Although 55% of salmon reported caught by anglers on these rivers were released alive, any impact of power station mortalities should be compared with the total catch (not fish killed), because recreational fisheries are valued per salmon caught.

19.6.305 No salmon were recorded in the long-term impingement monitoring programme at Hinkley Point between 2005 and 2009 and none were recorded in the CIMP (see Ref. 19.27).

19.6.306 On this basis, without mitigation, the predicted impact is considered to be **negligible**.

IMPACT: Twaite Shad due to Impingement

19.6.307 Spawning populations of twaite shad are confined to four rivers in the UK, namely the Rivers Tywi, Usk, Wye and Severn (including its tributary the River Teme). The twaite shad is a protected species, but there is only sparse population data for them in the Severn Estuary, so the potential for the estimation of shad stock sizes from current sampling techniques is limited and, as such, few estimates have been made. However, as part of the recent Severn Tidal Power Feasibility Study Strategic Environmental Assessment, an attempt has been made to estimate shad population size and age distribution using a simplified age-structured matrix model (Ref. 19.212).

19.6.308 The model described in Ref. 19.212 applies a matrix incorporating life-history parameters (adult survival rates; sex ratio; fecundity at weight/age; spawning propensity; and density-dependence) to predict the number of adult female shad within the River Severn RBD. The model incorporates a density-dependent egg deposition function based on a stock–recruitment relationship derived by M. Aprahamian (pers. comm., cited in Ref. 19.212) for adult females aged six years and applies forecasting and hindcasting methods using documented life history parameters to predict adult population size in a given year. For the purposes of this study, adults are considered to be aged between three and nine years old.

19.6.309 The model estimate indicates an average population size of approximately 92,000 female shad. Given a sex ratio of 1:1, the total mean population of twaite shad aged between three and nine years in the Severn RBD is therefore estimated to be 184,000, although variation in year-class strength may result in estimates ranging between 112,000 and 596,000.

19.6.310 Based on the scaled-up CIMP dataset, the total annual estimated impingement of twaite shad at a new power station at Hinkley Point, assuming a constant abstraction rate of $125m^3.s^{-1}$, without mitigation, would be about 2,276 fish (Ref. 19.43). As it is not currently possible to derive an EAV for twaite shad because of the absence of the necessary life history data, we have not rescaled the impingement estimates derived from the CIMP data. Therefore, with the present cooling water intake design, the equivalent adult numbers of twaite shad likely to be impinged annually at HPC (2,276 fish) equates to approximately 1.24% of the estimated local twaite shad population (184,000 adults).

19.6.311 On this basis, without mitigation, a **moderate adverse** impact is predicted, based upon a medium magnitude of effect and medium receptor value.

IMPACT: Eel due to Impingement

19.6.312 The Environment Agency monitors fish populations extensively within the Severn River Basin District (RBD), although the (mostly) multispecies electric fishing surveys used may underestimate the true density of eel (Ref. 19.213). The data suggest that eels are currently well distributed throughout the lower and middle parts of the catchments, and the Environment Agency has concluded that the eel population in the Severn downstream from Worcester has shown little change since the early 1980s, over the period when average recruitment to Europe has declined substantially (by 95% or more; Ref. 19.214).

19.6.313 The density and the biomass of eel in the middle reaches of the Severn and Warwickshire Avon catchments were low during the 1980s, but have not been

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surveyed in recent years. Similar survey data for the Bristol Avon catchment and Somerset rivers within the Severn RBD indicate a general decline in densities and biomasses between 1991 and 1993, and 1994 and 2006, by 37% and 48%, respectively.

19.6.314 A modelling approach to estimate the proportional impact of estuarine glass eel fisheries on the population is available (see Ref. 19.215 and 19.216) and, although it could be used here, it requires extensive sampling of glass eels during spring, when they enter the estuary.

19.6.315 In the absence of data on historical production of eel in England and Wales, a standard production rate of 16.9kg per hectare has been applied by the Environment Agency in estimating historic production and hence setting the 40% escapement biomass target (6.76kg per hectare) required under the European Eel Regulation 110/2007. This production rate was selected with reference to estimated production rates for the Bann (Northern Ireland) and Loire (France) catchments, reported by Ref. 19.217. Using the Environment Agency's Probability Model (Ref. 19.218), silver eel output from the Severn RBD is estimated to be about 8.4kg per hectare, which equates to about 133.4t of silver eel per year (Ref. 19.219). As such, the Severn RBD is tentatively assessed as exceeding its management target for silver eel production at this time. Note, however, that this model estimate is based on estimates of local yellow eel densities for 109 sites in the Severn catchment, extrapolated to the entire wetted area and converted to silver eel equivalents using a "silvering index", and therefore has a high degree of uncertainty.

19.6.316 Given Hinkley Point's location on the south coast of the Inner Bristol Channel seawards of the River Parrett, the potentially susceptible population consists of glass eels/elvers migrating upstream to freshwater, silver eels migrating downstream from freshwater, and any yellow eels living in the marine environment of the local area. Comparisons of glass eel and yellow/silver eel mortalities through impingement with population estimates are theoretically possible, but the models to permit this are still being developed and it is uncertain anyway which are the relevant 'populations'. The European eel is currently considered to comprise a single reproductive stock throughout its distribution range (and spawns in the Sargasso Sea off the Gulf of Mexico), and individual river and adjacent coastal marine populations appear to mix considerably.

19.6.317 The most useful indicator of impact is a comparison between impingement data for eels (although these are not differentiated by life stage) at Hinkley Point and estimates of the reported catch of each life stage 2005 to 2008 in the Severn Estuary RBD. A total of 774kg of glass eels was declared as caught in the Severn RBD in 2005, 684kg in 2006 and 1254kg in 2007. The declared annual catches of yellow eels in the years 2005 to 2007 were 4,088, 2,785 and 892kg respectively, and 419, 968 and 133kg of silver eels.

19.6.318 Based on the scaled-up CIMP dataset, the total annual estimated impingement of eels at HPC, assuming a constant abstraction rate of $125m^3.s^{-1}$, would (without mitigation) be about 1,304 fish, equivalent to 0.08t of adult eels. As it is not currently possible to derive an EAV for eels because of their complex life history, the impingement estimates derived from the CIMP data are not rescaled. With the present HPB cooling water intake design, the equivalent adult numbers of eels likely to be impinged annually at HPC (i.e. 0.08t) equates to <0.3% of a potential eel fishery (26t) and <0.06% of the local SSB (133.4t).

19.6.319 On this basis, without mitigation, a **moderate adverse** impact is predicted, based upon a low magnitude effect and the high sensitivity of the receptor. The impact of entrainment is considered separately below.

IMPACT: River and Sea Lamprey due to Impingement

19.6.320 More than half the UK SAC designations for the presence of either one or both of river and sea lamprey are situated on the Welsh coast, including the Rivers Wye and Usk. The most recent condition assessment round in 2007 classified all but the River Usk as unfavourable for river lamprey and all but the River Wye as unfavourable for sea lamprey. Stock status information is restricted to SAC rivers and is primarily in the form of ammocoete (larval lamprey) densities and distribution. The River Usk has the greatest *Lampetra* spp. ammocoete population across all British SAC rivers, and the River Wye has the greatest sea lamprey ammocoete population (Ref. 19.220).

19.6.321 Although river and sea lamprey are believed to spawn and reside within the River Severn, no assessment has been undertaken of their stock. However, as part of the Severn Tidal Power Feasibility Study Strategic Environmental Assessment, an estimate of lamprey population size and age distributions was derived (Ref. 19.212) using measurements of life-history traits collated from the literature to construct a generic life table for sea lamprey and river lamprey. Lampreys were assumed to represent one discrete population, given the species' capacity to disperse, as evidenced by their lack of homing and wide juvenile movement within several rivers throughout the UK. The life cycle of lamprey was represented by a stage-structured model and constructed with vital rate data and information on: average age at metamorphosis (ammocoete and parasitic juvenile); average ammocoete density per m^2 of optimal and suboptimal habitat; metamorphosis success (ammocoete to parasitic juvenile); ammocoete survival; and sex ratio.

19.6.322 Markov Chain Monte Carlo (MCMC) simulations were used to estimate the mean population size from the model output and provide a likely average population size of adult lamprey in the Rivers Usk and Wye. These estimates have been based on best guesses of available habitat of 1% per metre length of river for both optimal and suboptimal habitat. The population estimates are shown in **Table 19.28** (Ref. 19.212).

Table 19.28: Population Estimates of Lamprey (Mean ± s.d.) (Ref. 19.212)

	River Lamprey	Sea Lamprey
Usk	27,667 ± 4,696	3,069 ± 455
Wye	88,442 ± 14,326	12,200 ± 1,836
Total	116,109	15,269

19.6.323 Based on the scaled-up CIMP dataset, the total annual estimated impingement of river and sea lamprey at HPC, assuming a constant abstraction rate of $125m^3.s^{-1}$, without impingement, would be about 82 and 207 fish (Ref. 19.43), respectively. As it is not currently possible to derive an EAV for lamprey because of their complex life

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history, the impingement estimates derived from the CIMP data have not been rescaled. Therefore, with the present HPC cooling water intake design, the numbers of lamprey likely to be impinged annually at HPC equate to <0.07% of the river lamprey population and 1.36% of the estimated sea lamprey population.

19.6.324 On this basis, without mitigation, a **moderate adverse** impact is predicted based upon low magnitude and the high sensitivity of the receptor.

IMPACT: Fish Assemblage due to Impingement

19.6.325 The range of fish species assessed in some detail above is reasonably representative of the fish assemblage as a whole. In sum, a medium sensitivity and medium magnitude of effect may be assigned resulting, without mitigation, in an impact upon the local estuarine/marine fish assemblage of **moderate adverse** significance. See Ref. 19.14 for further discussion.

v. Entrainment

19.6.326 The aquatic organisms at risk of passing through the filtration system fall into three categories:

- Holoplankton representing those organisms that permanently exist within the plankton which are dominated by copepods within the Bristol Channel as with many other estuaries in the UK.
- Meroplankton representing those organisms which temporarily reside within the plankton including decapods, molluscs, echinoderms, annelids, shrimps, eggs and larvae (fish and invertebrate).
- Juvenile fish of a size small enough to allow them to pass through the drum screen mesh.

Assessment of Entrainment Loss (without mitigation)

19.6.327 The estimation of entrainment impacts associated with HPC (Ref. 19.27) has been carried out in accordance with best practice guidance contained in Ref. 19.18. Assumptions on cooling water system design are as for the Assessment of Impingement Losses, above.

19.6.328 The six anadromous species designated under the Severn Estuary, River Wye and River Usk SACs are: Atlantic salmon, twaite shad, allis shad, river lamprey, sea lamprey and sea trout. Being anadromous, the early life stages of the SAC species salmon, and the BAP species, sea trout are not likely to be vulnerable to entrainment as they will remain within freshwater during this life stage.

19.6.329 In addition, the juvenile life stages of these species present within the Inner Bristol Channel will be of sufficient size to avoid their passage through the 5mm drum screen mesh and would thus be subject to impingement mortality instead (Table 19.29) and likewise be subject to any means of mitigation associated with that impinged catch (see below). Lamprey transformers, glass eel, elvers and juvenile shad could however be vulnerable to entrainment as they may be present in the area at a size small enough to allow them to pass through a mesh size of either 5mm.

Table 19.29: Smallest Sizes of Various Fish Species Excluded by a 5mm Screen Mesh (Ref. 19.238)

Species	Smallest Size Excluded (Length, mm)
Eel, lamprey, pipefishes	100
Herring, salmon, common goby, sand-smelt, poor cod, whiting, sprat, grey mullet	40
Sea bass, shad, pouting	35

19.6.330 The previous entrainment studies at HPB and plankton studies within the vicinity of the site suggest that the eggs and larvae of the following key species are potentially at risk of being entrained through the cooling water system: sea bass, cod, eel, flounder, haddock, herring, lemon sole, plaice, pout, sole, sprat, gobies and whiting.

19.6.331 Entrainment estimates were determined on the basis that fish eggs and larvae would be entrained in direct volumetric proportion to their densities within the Bristol Channel within the vicinity of Hinkley Point (ICES rectangles 29E4, 30E4, 31E4, 30E5, 31E5 and 31E6, **Figure 19.33**). This assumption may be over-pessimistic. Ref. 19.221 found that the densities of fish larvae in Southampton Water were greater than those entrained from the entire water column, indicating that larvae were able to avoid entrainment and that actual entrained numbers were significantly lower than would be expected from offshore plankton surveys. At Bradwell Power Station on the Blackwater Estuary in Essex, entrainment monitoring for sole eggs and fry sampled just a single egg during seven weeks on-site. Whether the differences observed in this study or the previous studies are a result of the sampling techniques or a result of patchy distribution of plankton is unknown, but it has been suggested that it may in part be due to stratification of larvae in the water column (Ref. 19.222).

Entrainment of Other Zoo- and Phytoplankton

19.6.332 Other types of plankton will enter with the cooling water and are not likely to resist entrainment, although patchiness and stratification may affect their susceptibility. BEEMS surveys at HPB indicate that crustacea form an important component of entrained holoplankton (e.g. the seasonal mysid *Schistomysis spiritus*). Phytoplankton levels, primarily comprised of diatoms, are low in the Bridgwater Bay area of the Bristol Channel, owing to high turbidities, and consequently zooplankton are limited. As noted earlier in this Chapter, copepods are the dominant zooplankton in the waters off Hinkley Point.

19.6.333 Aquatic organisms entrained through the travelling screen mesh and into the cooling water system are at risk of a number of mechanical, hydraulic, pressure, temperature and chemical related stressors during this passage. The survival of entrained individuals is dependent upon the species, their developmental stage and size, physiological condition and the design of the cooling water system.

IMPACT: Entrainment of Phytoplankton

19.6.334 In a series of experiments at Fawley power station the author of Ref. 19.250 demonstrated that, in the absence of chlorination, primary production was enhanced by increased water temperature up to a discharge temperature of 23ºC but thereafter was progressively inhibited. No significant net loss in phytoplankton productivity was found at discharge temperatures of up to 27ºC. The author concluded that the entrainment effects of mechanical damage and thermal shock on phytoplankton were negligible.

19.6.335 That same study found that primary productivity was reduced by approximately 60% with a chlorination level of 0.2mg.l^{-1} and a Δt of 10ºC. It was not clear if the phytoplankton cells were killed or temporarily inhibited. For experimental reasons cells had to be cultured in chlorinated water for 3 hours, which is not representative of the short exposures in a power station (e.g. 18 minutes for HPC). Such exposure may have increased the measured effects.

19.6.336 Ref. 19.250 describes results from laboratory experiments on the effects of thermal shock upon the diatoms *Phaeodactylum tricornutum* and *Gyrosigma spencerii*. Neither species were significantly affected when cultured at 12ºC or 16ºC by thermal shocks of up to 17ºC. Both species were killed at ambient temperatures of 24ºC and a Δt of 15ºC. Growth was inhibited at a Δt of 10ºC and Δt of 12ºC respectively. The LT50 (lethal temperature to 50% of the species) was 36.5ºC and 37ºC respectively.

19.6.337 The flagellate *Dunaliella tertiolecta* was more resistant and survived an exposure time of 40 minutes at a final discharge temperature of 41ºC; cell growth stopped for 5 days and then recovered to densities similar to the control within 12 days.

19.6.338 The 98%-ile predicted discharge temperature of HPC is 32.9°C (i.e. below the below expected LT50 values (Ref. 19.250)). No loss of productivity is expected at a discharge temperature of 31ºC. At 34ºC there is a possibility of a small reduction in growth, but this may not be noticeable in the enhanced productivity of the warmer receiving waters. In the absence of chlorination the thermal effects of entrainment on primary production are thus expected to be **negligible**.

19.6.339 If chlorination resulting in an in-circuit level of 0.2mg.l^{-1} TRO were employed by HPC, the available evidence (Ref. 19.250) suggests that an approximate 60% reduction in productivity would be expected in entrained phytoplankton. Making worst case assumptions that the effected cells were killed and that HPC extracts 1% of the available source (plume) volume per day (Ref. 19.27) within the zone of abstraction, then 0.7% of the phytoplankton cells in that plume volume would be killed per day. Assuming phytoplankton are uniformly distributed over the entire Inner Channel, HPC could kill 0.05% of the Inner Channel phytoplankton abundance per day. The overwhelming majority of phytoplankton production and consumption by copepod zooplankton takes place outside of the Inner Channel and outside of the influence of HPC (Ref. 19.255).

19.6.340 The predicted recirculation of the HPC discharge water into the intakes is slight (Ref. 19.38). Moreover the reduced phytoplankton abundance in the HPC discharge water would rapidly be restocked from phytoplankton cells from elsewhere in the Channel that are outside of the HPC abstraction zone. Under such circumstances the impact on phytoplankton productivity would be **negligible**.

IMPACT: Entrainment of Zooplankton (1) copepods

19.6.341 A comprehensive review of entrainment survival for over 20 power stations in the USA determined a mean survival rate for a range of aquatic organisms and lifestages of over 50% (Ref. 19.223). Survival rates were highest for macroinvertebrates (72 to 92%) and lowest for sensitive fish species such as herring (mean values approaching 25%). Effects from physical, temperature and chemical stressors differed between the species. As would be expected survival was lowest for the delicate early larval stages and highest in early juveniles. For clupeids survival rates of juveniles ranged from zero to 81.5% with an average of 25%. Similar survival rates were also observed for clupeid larvae ranging from zero to 70%.

19.6.342 Ref. 19.224 describes the development of an entrainment mimic unit (EMU) designed to mimic realistically the conditions of entrainment passage through the cooling water system of a coastal power station under laboratory conditions as a means of assessing likely mortalities of entrained organisms. The apparatus allows the assessment of the effects of the four key stressors of entrainment: temperature, pressure, biocide and mechanical effects, alone and in combination. Their original experiments on larvae of the Pacific oyster *(Crassostrea gigas)* gave a baseline comparison of the technique to a standard bioassay technique (the D-stage larval test) and demonstrated the suitability of the apparatus and experimental protocols to assess the impacts of power-station entrainment.

19.6.343 A study reported in Ref. 19.250 calculated that the natural mortality of the copepod *Eurytemora affinis* in the Inner Channel was approximately 33 yr^{-1} i.e. 8.6% per day. This value was not atypical for copepods found in similar temperatures. Annual mortality ranges for *Acartia* spp. were reported as 17-58 yr^{-1} with higher figures of up to 257 yr^{-1} reported for tropical latitudes.

19.6.344 As noted above, the dominant members of the plankton at Hinkley Point are members of the genus *Acartia* and an assessment of the likely impact upon this genus alone thus has value in terms of indicating the likely scale of impact on the local holoplanktonic assemblage as a whole. After Ref. 19.250, this assessment makes the following assumptions: 1.1% of plume volume entrained per day (Ref. 19.27); entrainment mortality 20% (from EMU experiments, Ref. 19.200); ratio of plume volume to volume of Inner Channel =7.2%; copepods uniformly distributed throughout the Inner Channel. The entrainment mortality in the summer at Hinkley Point will represent 0.016% of the Inner Channel population per day. Ref. 19.253 and further studies described by Ref. 19.250 show that the population of *Acartia* spp. is distributed over the entire Central and Inner Channels in the summer and, therefore, the percentage of the Bristol Channel population that will be killed by HPC is less than 0.004%. Given the natural productivity of the species this will cause a **negligible** impact.

IMPACT: Entrainment of Zooplankton (3) Sabellaria larvae

19.6.345 As noted earlier in this Chapter, reefs of the tube building worm, *Sabellaria alveolata,* are found to the west of Hinkley Point and along the low shore directly in front of the station, as well as on some low shore areas of Stert Flats.

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19.6.346 As described by Ref. 19.250, there is evidence from laboratory experiments that *S.alveloata* spawns briefly in July and the larvae spend a minimum of six weeks and a maximum of eight months in the plankton. Field observations on larval settlement have proved variable from year to year but peaks have been detected off the Cornish coast in September to November and December. On the French Atlantic coast peak larval densities have been reported from October to March and spawning has been reported in the Bay of Mont-Saint-Michel in early May with a settlement time of 12 weeks and then September with a settlement period in the 8ºC warmer water of four weeks.

19.6.347 Larvae settle principally on old colonies and detect the cement used by tube building worms of *S.alveolata* or *S.spinulosa*. Natural mortality has been estimated by field measurement to be 0.09 d^{-1} (range 0.089 to 0.097 d^{-1}). These values were in the range of marine invertebrate mortalities described elsewhere (Ref. 19.250) (mean of 23 species 0.23 d^{-1}, range 0.016 to 0.82). There is evidence for vertical migration with larvae moving towards the surface during the flood tide during the day as well as at night.

19.6.348 *S.alveolata* growth is promoted by high levels of suspended sediment and higher water temperatures. In the UK it is at or near the northern edge of its thermal range and it can suffer high mortalities in cold winters.

19.6.349 The planktonic life stage of *S. alveoloata* is the only stage vulnerable to entrainment. There are no published data on the entrainment mortality of *Sabellaria* larvae. Ref. 19.44 found no adult mortality for *S. spinulosa* after a 28 day exposure to chlorine at 0.1mg.l^{-1} at 15ºC ambient. Ref. 19.52 reports an EC50 for a 5min exposure at 0.3mg l^{-1} for the polychaete *Phragmatopoma californica* (temperature not specified). In the absence of more data a 50% mortality has been assumed for HPC with chlorination at 0.2mg l^{-1} TRO.

19.6.350 Modelling of the potential abstraction of *Sabellaria* larvae released from potential spawning areas in Bridgwater Bay by particle tracking in the HPC GETM model (Ref. 19.261) predicts a 0.05% chance of larval abstraction per day for four intakes. Assuming 50% entrainment mortality, the predicted worst case loss of *S.alveolata* larvae is 0.025% per day. Natural mortality is approximately 9% per day (Ref. 19.250). In practice the risk of abstraction will be less than calculated because no account has been taken of larval dispersion into the wider channel. The resultant increase in natural mortality from 9% to 9.025% is considered to be of **negligible** significance.

IMPACT: Entrainment of Zooplankton (4) mysids

19.6.351 From Refernece 19.250 the main mysids found in the Inner Bristol Channel and the Hinkley Point forebay have been observed to be (by % number): *Schistomysis spiritus*, 66%; *Mesopodopsis slabberi*, 20%; *Gastrosaccus spinifer*, 11%; *Neomysis integer*, 4%.

19.6.352 Mysids are part of the hyperbenthic community and are normally found within 1m of the seabed. Maximum concentrations are found just below the low water mark in summer and near to the 5 to 10m contour in winter. They indiscriminately feed on fine particulate matter including detritus, algae, zooplankton and sand grains. Mysids are good swimmers and can maintain 10 body lengths.s^{-1}. They can maintain their position even in strong currents by sheltering on the seabed. Mysids are an important part of the diet of *C.crangon* and fishes in the 3-15cm length category.

19.6.353 Ref. 19.250 reports very limited data availability on entrainment mortality for mysids and thus, as a precautionary measure, a 100% mortality rate is assumed in this instance. After Ref. 19.250, this assessment makes the following assumptions: 1.1% of plume volume entrained per day (Ref. 19.27); entrainment mortality 100%; ratio of plume volume to volume of Inner Channel =7.2%; mysids uniformly distributed throughout the Inner Channel.

19.6.354 On the basis of this assessment, the additional mortality in the Bristol Channel from entrainment losses associated with HPC will be 0.08% d^{-1} (predominantly to juveniles). The natural mortality of mysids is 4% d^{-1} (adults) to 6% d^{-1} (juveniles); hence there will be a **negligible** increase in mysid mortality due to entrainment.

IMPACT: Entrainment of Zooplankton (5) Crangon

19.6.355 Ref. 19.240 concluded that, in combination, the stresses of entrainment under standard power-station operating levels would result in approximately 20% mortality of brown shrimp larvae (from the combination of total residual oxidant (TRO), and rise in temperature (ΔT).

19.6.356 Using morphometric measurements a study reported by Ref. 19.250 determined that the Bristol Channel *C. crangon* population (east of the line Nash Point to Porlock Bay) is distinct from its south-western sea neighbour. *C. crangon* is impinged at HPB throughout the year with peak abundance in the period July to November and minimum abundance in April/May. At Bridgwater Bay *C. crangon* (mostly juveniles) migrate with the rising tide onto the high intertidal flats. At low water the population is concentrated near the low water mark and HPB catches are largest; typically 7 times those at high water. Spawning takes place twice a year in January and late spring/early summer; the females migrate offshore to the west to release their eggs. Mature males remain offshore to mate with returning females. The January spawning leads to egg hatching at the end of March/early April with metamorphosis and settlement on the intertidal area in early to mid May. The early May spawning hatches in early June with settlement in mid July.

19.6.357 *C. crangon* larvae are not been found in the monthly plankton sampling at HPB. This is in agreement with Ref. 19.253 who found highest density of *C. crangon* larvae in the Outer Bristol Channel. The size of the annual recruitment is therefore determined by environmental factors outside of Bridgwater Bay and not the influence of HPB or HPC. The lifecycle stages of *C. crangon* that are vulnerable to impingement and entrainment are thus juveniles and predominantly mature females that utilise the lower parts of Stert flats.

19.6.358 With a 10mm inlet screen mesh at HPB, approximately 38% of *C. crangon* that are drawn into the cooling water system have been estimated as being impinged and the rest are entrained and pass through the condensers (after Ref. 19.250; figures calculated using typical length frequency distribution of *C. crangon* and reported

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impingement probabilities). With the proposed 5mm drum screen mesh of HPC approximately 90% of the animals will be impinged and 10% entrained.

19.6.359 Bamber has produced results from EMU experiments using *C. crangon* larvae (Ref. 19.225). These experiments showed no effect from pressure, mechanical damage or direct effects for a ∆T of 12ºC or from chlorination. The work did show that elevated temperatures increased the animal's sensitivity to chlorine. Typical power station mortality with chlorination was estimated to be 25% (at a final discharge temperature of 23ºC).

19.6.360 No results from juvenile or adult *C. crangon* are available. Ref. 19.250 reports an estimated maximum temperature for *C. crangon* to survive of 30ºC based upon physiological considerations. However this estimate is not the same as the critical temperature for survival in a 20 minute entrainment exposure. Ref. 19.21 summarises thermal ULT for invertebrates as falling within the range 30-33ºC and for decapods as a mean of 32.9ºC. As a result, in the months of July or August, there may be some thermally induced mortality associated with HPC. The EMU derived 25% mortality applied to larvae, but *C. crangon* larvae are not abstracted at Hinkley Point. In principle it would be expected that juveniles and adults would be less sensitive to chlorine but in the absence of additional data the 25% mortality has been used in entrainment calculations for HPC with or without chlorination.

Table 19.30: *Crangon Crangon*: Annual Impingement and Entrainment Impact of HPC Options Compared with HPB.

Station	Impinged (m)	Loss (m)	Loss (t)	Entrained (m)	Loss (m)	Loss (t)	Total Loss (m)	Total Loss (t)
HPB	**4.9**	**4.9**	**3.6**	**12.9**	**0**	**0**	**4.9**	**3.6**
HPC 10mm mesh, No Cl	19.1	3.8	2.8	50.3	0	0	3.8	2.8
HPC 10mm mesh Cl at 0.2mg.l^{-1}	19.1	3.8	2.8	50.3	12.6	2.6	16.4	5.5
HPC 5mm mesh, No Cl	**43.0**	**8.6**	**3.9**	**26.4**	**0**	**0**	**8.6**	**3.9**
HPC 5mm mesh, Cl at 0.2 mg.l^{-1}	**43.0**	**8.6**	**3.9**	**26.4**	**6.6**	**0.4**	**15.2**	**4.3**

(m)=millions; (t)=tonnes

19.6.361 Ref. 19.250 provides an analysis of the annual impingement and containment impact of HPC (**Table 19.30**) and notes that the existing Bristol Channel population of *C. crangon* is density limited. Any reduction in local biomass due to HPC will rapidly be filled by a population that grows on average by 5% per day during the summer. The evidence from the HPB impingement surveys is that the production/biomass ratio has increased over the past 27 years.

19.6.362 Ref. 19.250 also notes that the estimated production at Stert flats is 1781kg.km^{-2}, i.e. the production from Stert/Berrow flats is 85 tonnes and the 200km^2 of the Bristol Channel inter-tidal flats is 356 tonnes. Estimated losses from HPB at present would thus amount to 1% of the annual production of *C. crangon* within the Bristol Channel, HPC with no chlorination 1.1% and with chlorination 1.2%.

19.6.363 There is therefore no significant difference between the total predicted losses from HPC (with its 5mm inlet mesh) and the existing HPB station. If HPC needs to chlorinate, losses could be further reduced from those shown above by adopting a 50:50% chlorination duty cycle. Under such circumstances the total losses would reduce to 1.1% of the Bristol Channel production.

19.6.364 On the basis of the findings described above, an impact of **minor adverse** significance upon *C. crangon* is predicted on the basis of very low sensitivity and a medium magnitude effect.

IMPACT: Entrainment of Zooplankton (6) ichthyoplankton

19.6.365 **Table 19.31** shows that entrainment survival rates for fish eggs may be high (80+%) and that survival rates for fish larvae are lower and more variable.

Table 19.31: Survival rates of entrained fish and crustacean from EMU cooling water passage simulation experiments (Ref. 19.225)

Species	Life Stage	Entrainment Survival Rate at 0.2ppm TRO and approximately10°C ΔT	Prime Causes of Mortality
Sole (*Solea solea*)	eggs postlarvae	93% 8%	pressure, thermal stress thermal stress and chlorine toxicity
Turbot (*Psetta maxima*)	eggs post larvae	93% 30%	pressure, thermal stress thermal, mechanical and pressure stress
Sea bass (*Dicentrarchus labrax*)	eggs larvae	54% 56%	thermal stress thermal stress and chlorine toxicity
Eel (*Anguilla anguilla*)	larvae*	52%	TRO
Shrimp (*Crangon crangon*)	larvae	75%	thermal stress and chlorine toxicity
Lobster (*Homarus gammarus*)	larvae	92%	mechanical stress

Note: **Eel tested at 2ppm TRO*

19.6.366 Ichthyoplankton varies spatially throughout the Bristol Channel, being highest for eggs in the spawning areas (particularly around Trevose Head, some 100 miles along the coast to the West of Hinkley Point, for most commercial species), and may also be high nearshore where larvae and post-larvae begin to recruit to nursery areas (e.g. for sea bass, see Ref. 19.226). In this respect, the water entrained at Hinkley Point will not be representative of other areas of the Bristol Channel, although the inner reaches of the Severn Estuary are well mixed. The Trevose Head spawning grounds are used here as a reference area.

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19.6.367 Ichthyoplankton surveys off the Hinkley Point area were undertaken quarterly in 2008 and again in May 2009 (Ref. 19.33). Eggs and larvae of just 14 species were detected in very low numbers (**Table 19.32** shows which species were detected during 2008/9). However, those surveys were designed to increase understanding of the subtidal ecology of the area and not just the ichthyoplankton community, so the timing of the surveys in 2008 were not optimal for the main fish spawning season.

Table 19.32: Presence (+) of Fish Eggs and Larvae Detected in Ichthyoplankton Surveys off Hinkley Point in 2008 and 2009

Species	Eggs	Larvae
Anchovy	+	
Dover sole	+	+
Rockling spp.	+	
Solonette	+	+
Sea bass	+	+
Gurnard spp.	+	
Dragonet		+
Herring		+
Sprat		+
Sandeel		+
Goby spp.		+
Mackerel	+	
Pilchard	+	
Scaldfish	+	

19.6.368 In order to obtain a better estimate of ichthyoplankton communities at the site, intensive monthly surveys were undertaken between February and June 2010 (Ref. 19.34). Despite this greatly increased sampling effort, the eggs and larvae of only 18 species were detected, although much better temporal and spatial density estimates were obtained. The 2010 surveys confirmed the findings of the 2008 and 2009 surveys that the Hinkley Point area has a very limited ichthyoplankton community and therefore the risk of entrainment loss is both low and is limited to a narrow range of species.

19.6.369 Although eggs and larvae of 18 species of fish were detected in the BEEMS intensive plankton survey off Hinkley Point in 2010 (Ref. 19.34), comparison with abundances at the Trevose spawning area have only been made for European sea bass, Dover sole, and sprat because these are the only ones of commercial interest identified during the BEEMS plankton surveys that can be compared with those species present.

19.6.370 The estimated entrainment of eggs and larvae over the period February to June 2010 given in **Table 19.33** has been made assuming:

- no exchange between the pool and adjacent sea areas;

- uniform distribution and abundance of ichthyoplankton throughout the water column; and
- the mean ichthyoplankton abundances from the 2010 surveys close to Hinkley Point power station occur within the identified 'pool'.

Table 19.33: Predicted Entrainment of Fish Eggs and Larvae between February and June 2010 at Hinkley Point C (based on the Ref. 19.34) in relation to the abundance in the Trevose spawning area

Species/ Species Group	Eggs	Larvae	A: Total**	B: Trevose	A/B
Sandeels		9,075,949	9,075,949		
Solenette	368,278	2,496,257	2,864,536		
Five-bearded rockling		333,687	333,687		
Herring		414,615	414,615		
European sea bass	47,282,931	41,981,786	22,051,122	29,206,261,000	0.11%
Rockling	18,546,479	799,420	19,345,899		
Gobies		10,351,234	10,351,234		
Butter fish		389,819	389,819		
European flounder		2,711,333	2,711,333		
European plaice		3,322,735	3,322,735		
Pilchard	2,891,002	386,310	3,277,311		
Dover sole	9,461,839	1,929,208	1,659,991	274,633,000,000	0.001%
Soles*	450,281	369,308	819,589		
Sprat		7,114,303	7,114,303	478,943,000,000	0.001%
Sea scorpion		474,262	474,262		
Unidentifiable fish	5,004,020	21,322,227	26,336,246		

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Species/ Species Group	Eggs	Larvae	A: Total**	B: Trevose	A/B
European anchovy	12,141,963		12,141,963		
Dragonets	383,685		383,685		

* *Indicates eggs and larvae that, due to damage, could not be confirmed as Dover sole, but were identified as belonging to the family Soleidae.*

** *For Dover sole and sea bass, the results have been adjusted so as to account for estimated survival based on EMU experiments.*

19.6.371 These entrainment estimates can be compared and put into context with the abundance of ichthyoplankton at the Trevose Head ground by examining the mean abundance of the same species in the Trevose spawning area (Ref. 19.227), ICES rectangles 29–31E4, 30–31E5 and 31E6 (**Figure 19.33**), assuming that:

- the mean abundances of eggs and larvae from the 1990 surveys were within the ICES rectangles 29–31E4, 30–31E5 and 31E6;
- the mean abundances of eggs and larvae from the 1990 surveys are still a reasonable approximation of the current situation; and
- the assumptions about the distribution and abundance of ichthyoplankton within the Trevose spawning area will be the same as that within the 'pool', i.e. uniform distribution and abundance throughout the water column.

19.6.372 Within the period February to June 2010, the predicted numbers of eggs and larvae of sea bass entrained by HPC are predicted to be <0.45% of the mean abundance within the Trevose spawning ground. For sole and sprat the numbers of entrained eggs and larvae over the same period are predicted to be <0.005% of the mean abundance within the Trevose spawning ground. Although the figures assume 100% mortality of all entrained organisms, previous EMU studies have indicated that this is not likely to be the case (but see the caveats above), in which case the impacts of entrainment mortality on local populations would be reduced further. Ongoing EMU trials under the BEEMS programme are investigating entrainment survival rates for relevant species and life stages and using exposure conditions based on the HPC cooling circuit design.

19.6.373 For certain species of conservation interest, such as shads (twaite and Allis) and lampreys (marine and river), that spawn and live as larvae in the freshwater tributaries of the Severn Estuary, entrainment of these early life history stages at HPC is expected to be negligible.

19.6.374 On the basis of the findings described above, an impact of **minor adverse** significance upon the ichthyoplankton is predicted on the basis of low sensitivity and low magnitude.

IMPACT: Entrainment of Zooplankton (7) glass eels

19.6.375 The majority of any glass eels abstracted by HPC will be entrained as they will be small enough to pass through the 5mm inlet screen mesh (Ref. 19.250). Glass eels enter the Bristol Channel in February to April and assuming the same efficiency as in the Gironde, the eels will migrate through the estuary at approximately 3 to 4km.d^{-1} using selective tidal stream transport.

19.6.376 The natural mortality of glass eels (i.e. excluding fishing mortality) has been estimated to be in the range 0.0233 – 0.0049 d^{-1}.

19.6.377 Glass eels entrained at HPC would be subject to mortality from:

- mechanical damage from the impellors n the cooling water pumps;
- thermal shock ; and
- exposure to chlorination for an 18 minute period inside the plant at 0.2mg.l^{-1} at the inlet to the condenser (If HPC uses chlorination).

19.6.378 Ref. 19.250 reports that the expected mortality from the temperature and chlorination regime described above would be negligible. HPC will employ cooling water pumps that are the same or close equivalents to those designed for Flamanville 3. These pumps were modelled in the STRIKER programme that has been widely applied to other pump mortality calculations (Ref. 19.225). The predicted mortalities ranged from 1.6% for a 70mm glass eel to 1.8% for an 80mm eel. The total entrainment mortality due to the cooling water pumps assuming a worst case 80mm eel is 1.8%.

19.6.379 After Ref. 19.250, this assessment makes the following assumptions: 1.1% of the plume volume is abstracted per day (Ref. 19.27); the mortality of entrained eels is 1.8% to 15%, i.e. the daily mortality is 0.02% to 0.165% of eels within the plume volume. Assuming that glass eels use the whole Channel to migrate, the daily mortality in the Inner Channel due to entrainment would be 0.0014% to 0.012%. Taking a mean value for natural mortality of 0.01 d^{-1} (or 0.995%), entrainment through HPC would increase the mortality of glass eels to within the range 0.996% to 1.007%. Such increases are considered to be of **negligible** significance.

19.7 Cumulative Assessment

a) Construction

i. Introduction

19.7.1 This section considers whether any of the identified effects associated with individual components of the HPC development could be additive or combine in such a manner that they could lead to a change (e.g. increase in effect or alteration in an area affected) that would be different to that determined for the individual components alone. The potential for cumulative impacts with other components of the HPC Project, namely Combwich Wharf, are considered in **Volume 11** Cumulative Effects. It should be recognised, however, that because of the spatial separation between the individual project components, their temporal extent and their localised effects on marine ecology, the potential for any interaction and therefore for such cumulative effects to occur is very limited.

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ii. Cross-shore Works

19.7.1 Works across the shore include: jetty construction, operation and removal; drilling of the horizontal tunnels for the cooling water structures; and seawall construction. The impacts of these activities will be additive in terms of the areas impacted, save where access corridors coincide.

19.7.2 During construction of the seawall, excavation works may lead to an increase in suspended sediments in the water column. However, the seawall is located on the uppermost part of the shoreline, above MHWS, and any discharges from the construction area, even if they contained relatively high suspended sediment concentrations, would be rapidly dispersed under high tide conditions. It is anticipated that background conditions would be achieved close to the points of discharge. Even under low tide conditions, it is not anticipated that the seawall works would contribute sufficient suspended sediment to reach the *Corallina* community present on the lower to mid shore. Should some discharge reach the area of *Corallina* it is likely to replicate events occurring naturally during rainfall events and the materials would be quickly re-suspended and transported elsewhere by the tide. Therefore, a combined impact due to the seawall construction with either the jetty piling works or the drilling of the horizontal tunnels (see below) is not predicted to occur.

19.7.3 Drilling of the horizontal tunnels is anticipated to take place during the operational stage of the jetty, and as such there would be no possibility for interaction between the construction stages. It is also anticipated that any discharge from the drilling works would occur over an area of the foreshore to the east of the jetty and would not impact upon the same intertidal area. Consequently, while a greater overall extent of foreshore supporting *Corallina* would be affected cumulatively, the same area of foreshore would be unlikely to be impacted by both activities. Following the end of the drilling works, the foreshore would not be disturbed again by activities until the dismantling of the jetty.

19.7.4 Overall it is concluded that while the foreshore at Hinkley Point may be subject to a number of construction related disturbance events, the totality of these events would be one of prolonging the overall period of effect across distinct parts of the foreshore, rather than intensifying impacts, such that a longer term loss or change in habitat function would occur. With the application of best practice described above and in **Section 19.8** below, specifically the use of constrained corridors for working and access, management of waste solids and liquids, appropriately designed roadbeds and use of appropriate vehicles to limit compaction of the cross-shore rock superficial limestone platforms (as also discussed in **Volume 2**, **Chapter 17**), the accumulated residual impact is predicted to be **minor adverse**.

iii. Sub-tidal Works

19.7.5 The offshore works which could result in cumulative impacts include the installation of jetty piles, dredging associated with the berthing pocket of the jetty, and the installation of the vertical shafts for the cooling water system.

19.7.6 The jetty will be in its operational phase during the installation of the vertical shafts and, hence, no cumulative impacts on marine life through increased suspended sediments or disturbance will arise. The capital dredging for the berthing pocket will also have been complete, but there is the potential for maintenance dredging of the berthing pocket to overlap with the installation of the vertical shafts.

19.7.7 Sensitive benthic habitats which could be impacted by this work include *Sabellaria spinulosa*, although there is no observed occurrence of this reef within 500m of the jetty. There is the possibility that some sub-tidal *Sabellaria* is present around the vertical shaft sites, however, given the habitat type involved this would not include any reef formations. It is therefore considered that, with the application of best practice, there will be **no cumulative impact** from increased suspended sediments on sensitive habitats due to the proposed sub-tidal works.

iv. Cross-shore Discharges

19.7.8 All cross-shore discharges will be via a single point of discharge specifically selected to avoid low water cross-shore flows intersecting with sensitive receptors.

19.7.9 The assessments included above relate to the cumulative effect of both construction and early commissioning discharges being passed via the same route. The accumulated residual impact, with mitigation, thus remains **minor adverse**.

b) Operation

i. Impingement and Entrainment

19.7.1 The AEV methodology applied in this instance has not involved the integration of impingement and entrainment losses for the very simple reason that ichthyoplankton have been found to occur at Hinkley only in very low numbers. As a result, the conclusion reached for the cumulative impact of impingement and entrainment remain identical, prior to mitigation, to those given above for impingement alone for each of the individual species considered.

19.7.2 As noted above, the larvae of the brown shrimp *C. crangon* do not occur locally so it is the consideration of adult and juvenile individuals alone that contribute to the impact of HPC on the population of this species.

19.8 Management Controls and Mitigation Measures

a) Introduction

19.8.1 The following sections contain a description of the specific mitigation measures considered to be appropriate, along with specific mitigation for each operation activity, where required, to reduce identified significant adverse impacts on marine ecology to acceptable levels.

19.8.2 As described in the **Construction Method Statement** which forms **Annexe 2** to this ES, a suite of Environmental Management Plans will be implemented to ensure that best working practices and required environmental mitigation measures are implemented. An Environmental Management and Monitoring Plan (EMMP) will provide the overall framework of environmental requirements and Construction

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Environmental Management Plans (CEMPs) will show how the contractor(s) will comply with the EMMP and any SSMPs.

19.8.3 Recognised best practice and regulatory guidance will apply wherever appropriate, for example by use of Environment Agency Pollution Prevention Guidance notes (PPGs).

19.8.4 In terms of the marine ecological sensitivities described earlier in this chapter, a clear example of the need to apply best practice will be in the control of works in the intertidal area, where appropriate means will be applied both to limit physical damage to fragile limestone pavement areas, and guard against the release of potentially polluting materials.

19.8.5 Likewise, the need to apply best practice will also apply to the management of offshore works.

19.8.6 The primary means of obtaining mitigation is through appropriate engineering design and subsequent management of plant. To accomplish this requires both a width of experience in building and operating such plant in a wide variety of circumstances over many years, together with a detailed multidisciplinary understanding of the environment into which new plant is to be introduced.

19.8.7 A significant element of HPC has been that precisely the same studies that have provided an understanding of potential environmental impacts have been employed in supporting considerations of detailed plant design where any element of that design or function encroaches upon, or depends upon, the structure and functioning of these marine systems.

b) Construction

i. Introduction

19.8.1 The primary means of mitigating impacts on the ecology of the local coastal environment during the construction of HPC will be appropriate engineering design combined with the application of best practice in terms of the management of construction and subsequently the plant itself.

ii. Habitat Loss and Change

19.8.2 Works on the seawall will be limited to a defined corridor along the top of the intertidal area and all associated works managed so as to prevent more widespread disturbance to the middle and lower intertidal areas and, in particular, the loss of control of any solid or liquid arisings from the works.

19.8.3 In bringing rock armour to the site by sea and landing these materials on the intertidal shore by barge, the following constraints would apply:

- barge deliveries would be limited to the within the inner perimeter shown by **Figure 19.36** (upslope of *Sabellaria* biotope, east of [*Fucus serratus*]/[*Ascophylum*] platform, west of [*Fucus serratus*]/[*Ascophylum*] platform); and

- unloading and transport of materials towards the sea wall construction zone will also be limited to that area.

At no point would vessels be permitted to ground against the intertidal shore outwith that inner perimeter.

19.8.4 There will be limited impact in terms of disturbance to the biotopes involved within the berthing area (hydrolittoral soft rock; [*Macoma*] and [*Arenicola*] in muddy sand shores; [*Fucus vesiculosus*] on variable salinity mid eulittoral boulders and stable mixed substrata/[Fucus serratus] and [large *Mytilus edulis*] on variable salinity lower eulittoral rock; [*Fucus spiralis*] on sheltered variable salinity upper eulittoral rock; [*Pelvetia calanaliculata*] on sheltered variable salinity littoral fringe rock; barren littoral shingle). These biotopes and habitats are widely distributed and common on local rocky shores and all would be expected to recover quickly from any superficial and localised loss of flora or fauna due to disturbance.

19.8.5 Unless managed sensitively, works to construct the temporary aggregate jetty will cause disturbance to the limestone and shale fabric of the cross-shore rocky platform which supports the *Corallina* turf interest. The extent of this damage will be limited by restricting the works to within a predefined corridor extending no further than 20m to either flank of the line of the jetty. There is also likely to be a need to make good the microtopography of the shore and reinstate longshore drainage channels should localised damage occur. As a consequence, piers will be introduced from seaward rather than landward as far as it is practicable to do so. Damage to the superficial geology will be limited by use of an appropriate temporary roadbed established within the access corridor, rendering the magnitude of impact low.

19.8.6 The use of jack-up rigs over the lower shore could cause similar damage to the rock surface, though over a much reduced area. Where works pass across the area of the limestone platform that dominates the middle and lower intertidal areas, any damage to the existing microtopography and the associated long-shore drainage routes will be restored after both construction and removal of the jetty, rendering the magnitude of effect very low.

19.8.7 The temporary aggregate jetty will be piered throughout its length with the express purpose of limiting hindrance to the passage of wave and tide. The open structure of the jetty means it will have a very limited effect on sediment transport on the foreshore and the subtidal and the associated ecological interests.

19.8.8 The FRR discharge line will not be driven across the shore surface but introduced by microtunneling from landward under the seawall and intertidal shore to reach a seabed outfall. Thus, aside from the temporary aggregate jetty, no cross-shore structures are to be introduced.

19.8.9 As described below, there will be a need to put construction and commissioning discharges across the shore from a discharge point at the head of the shore. In order to avoid areas of habitat that would be particularly sensitive to such flows, a number of possible outfall configurations have been tested in relation to biotope mapping. The location selected will not lead to flows entering the limestone platform

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drainage network leading to *Corallina*, and that flow will involve only limited areas of low sensitivity – see **Appendix 19.1** and **Figure 19.19**.

19.8.10 The connection between the HPC Development Site itself and the offshore cooling water intake and outfall headworks will be via tunnels bored under the shore and seabed from landward and, aside from these headworks themselves, there will be no structures on the seabed.

iii. Physical Disturbance

19.8.11 The mitigation measures for physical disturbance are the same as those outlined for loss of habitat above.

iv. Changes in Water Quality

19.8.12 Again, in terms of the potential for waste streams, the primary means of mitigating impacts on the ecology of the local coastal environment during the construction of HPC will be appropriate engineering design combined with the application of best practice.

19.8.13 Until such time as the cooling water system becomes available the intention is that construction and commissioning related effluents will be discharged across the intertidal area from a single dedicated discharge point. That discharge point has been selected on the basis of hydraulic modelling, which identified a location and route across the shore that avoided potentially sensitive and valuable biotopes – see **Appendix 19.1** and **Figure 19.19**.

v. Noise and Vibration

19.8.14 As noted in earlier sections, and for conservative purposes within this assessment, percussive piling is presumed for works associated with the aggregate jetty and the installation of cooling water headworks offshore.

19.8.15 Some risk of impact applies to both specific fish populations present in the immediate locality when such operations begin (particularly hearing specialists such as sprat and herring), and any marine mammals. The guidance provided by JNCC (Ref. 19.96) has been applied in terms of establishing a network of acoustic sensors offshore, but that guidance also suggests an appropriate ‘soft-start’ protocol for piling, and this will be adopted as a matter of precaution.

19.8.16 Soft-start is the incremental in crease in pile power over a set time period until full operational power is achieved. The soft start duration will be a period not less than 20 minutes. If there is a break in the piling operations for more than ten minutes, then the soft-start procedure will be repeated.

19.8.17 Once pile driving is initiated then the potential for physical damage effectively ceases as any fish within the zone of influence (ensonification) would move out of the area to avoid the increase in noise levels/pressure.

19.8.18 There are indications from initial use of the acoustic sensor network that porpoises are present in the area, albeit in low numbers. The decision whether or not to employ marine mammal observers during these works and apply the appropriate controls (Ref. 19.96) will be taken on the basis of further findings from this study in consultation with the relevant regulatory authorities.

vi. Artificial Lighting

19.8.19 The impacts predicted due to the presence of artificial lighting on the foreshore have been assessed as negligible and, therefore, no mitigation measures are required to minimise the impacts.

c) Operation

i. Introduction

19.8.20 The primary means of mitigating impacts on the ecology of the local coastal environment during the operation of HPC will be appropriate engineering design combined with the application of best practice in terms of the management of the plant itself.

ii. Thermal Discharges

19.8.21 As noted above, the primary means of mitigation is appropriate engineering design. In this instance, extensive oceanographic and ecological studies permitted the development and testing of a series of numerical hydrodynamic models (see **Appendix 18A to Volume 2, Chapter 18**) which, in turn, permitted the testing of a series of alternate intake and outfall configurations, shown in **Figure 19.7**.

19.8.22 By means of these tests an intake and outfall configuration was found that avoided recirculation of sea water from either the HPB or HPC outfalls, and accomplished a degree of separation of the two thermal plumes, thus limiting the compounding of any impacts on potentially sensitive areas, particularly the intertidal shores of Bridgwater Bay.

iii. Chemical Discharges

19.8.23 Although the impact of low level chlorination for the control of biological fouling within the cooling water circuits has been assessed as having a minor impact in relation to the EQS, a precautionary SL based upon provisional toxicity data suggests the need for a more conservative approach.

19.8.24 As a result, an application will be made for a permit to dose oxidant to the HPC cooling water systems but with an understanding that both the dose involved and the duration of the dosing period will be limited such in order to comply with the precautionary SL.

19.8.25 As the scope for growth of potentially fouling species such as the blue mussel *Mytilus* is already very limited, and that long-term experience at Hinkley Point suggests that the need for such dosing is infrequent, a limited dosing regime will prove operationally sufficient should the need ever arise.

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iv. Impingement of Fish and Shrimp

Regulatory Guidance

19.8.26 Environment Agency (best practice) guidance for mitigation of abstraction impacts at nuclear new build sites is given in Ref. 19.229; earlier material supporting this most recent guidance is Ref. 19. 230. This guidance is not mandatory, but adherence to it establishes common ground between the regulator and developer and helps to avoid development of unsuitable designs which might be damaging to marine/estuarine biota or might delay permitting of the project. The conservation agencies, NE and CCW, were also party to the development of the intake screening guidance and thus its application it is intended to meet their conservation objectives also.

19.8.27 For large, direct-cooled plant, the guidance recommends the following cooling water intake design features:

- Location of the cooling water intake away from fish spawning grounds.
- Maintenance of low velocities (target ≤0.3m.s^{-1}) at all tidal states (see next paragraph) via low velocity side entry (LVSE) intake design.
- A cap ('velocity cap') across the top of the intake to prevent vertical intake currents, which fish find it difficult to avoid.
- Fish deterrent system fitted to the cooling water intake structure to provide avoidance cues.
- Fish Recovery and Return (FRR) system to intercept and return any fish not repelled by the intake fish deterrent system (e.g. hearing-insensitive species).

19.8.28 On the low velocity criterion, the guidance proposes a default value of 0.3m.s^{-1} but allows higher values subject to a risk assessment based on fish swimming performance data provided within the guidance documents themselves. Such an assessment has been completed for HPC, as described below.

Intake Water Velocity

19.8.29 The offshore locations of the four HPC cooling water intake structures are not in the proximity of any known fish spawning grounds (Ref. 19.43). The intake design has been developed along the principles outlined in Environment Agency guidance, referenced there as the 'low-velocity side-entry' (LVSE) intake design (see **Figure 19.34**). Such a design has not previously gone beyond small-scale laboratory testing and the design developed for HPC has had to take account of factors other than fish protection, including the need for seismic qualification, harmonic stability and constructability, and hydraulic performance. Using numerical hydraulic modelling, the design adopted for HPC (see **Figure 19.34**) was tested against the LVSE concept-design and shown to offer more uniform low-velocity profiles and therefore to perform better than the LVSE reference design (Ref. 19.231).

19.8.30 The low-velocity intake design developed for HPC provides substantially lower velocities around the tidal cycle than the open-all-round cooling water intake structure of the HPA and HPB. Ref. 19.232 considered the effect of tidal stream velocities adding to pumped intake velocities at this type of offshore intake and showed that at Sizewell A, fish impingement peaked at maximum flood and ebb tidal velocities. At Hinkley Point, tidal stream velocities reach at least 1.5m.s^{-1}, and velocities for fish escape may exceed this value with the pumping effect added. An analysis of the effect of intake velocity differences between the proposed HPC low-velocity design and the HPB 'baseline' case on the ability of different species of fish to escape showed that, for the same 1.5m.s^{-1} tidal velocity, the EA LVSE reference design would result in velocities that would allow a further 16.1% of the fish impinged to escape (i.e. could reduce the impingement by 16.1%), while the HPC design would increase this reduction of impingement to a value of 52.2% (**Table 19.34**). These figures are given per unit of cooling water flow.

Table 19.34: Analysis of the HPB Impingement Catch showing % of Fish that would Remain Vulnerable to Capture with the Reduced Intake Velocities Modelled for the EA's LVSE Design and the Proposed HPC Intake Design

Intake Design	Tidal Velocity m.s^{-1}	% of Hinkley 'HPB' Fish below Escape Velocity						
		Shad	Sea bass	Sole	Whiting	Herring	Cod	All Six Species
HPC	1.5	41.8	27.8	38.5	50.9	30.6	49.8	47.8
EA LVSE Reference Design	1.5	79.5	54.2	77.9	85.8	79.6	85.0	83.9

Note: *Values were calculated using published swimming performance data and modelled velocities (Ref.19.231). Figures for 'All Six Species' are weighted according to annual catches at HPB.*

Acoustic Fish Deterrence

19.8.31 Acoustic fish deterrents (AFDs) will be fitted either to or near each of the four intake heads as the primary mitigation against fish entrapment. Environment Agency guidance (Ref. 19.229) advocates the fitting of AFDs at such cooling water intake structures to repel hearing-sensitive fish. These include pelagic species such as herring, sprat and shads, and moderately hearing-sensitive demersal fish such as cod and whiting. Epibenthic species, including flatfish, eels and lampreys are less sensitive and little influenced by AFDs, so the main mitigation against capturing these species will be through an onshore FRR system (see below).

19.8.32 The AFD system at HPC will be of the sound-projector-array (SPA) type (Ref. 19.230). The number and positioning of sound projectors will be determined by acoustic modelling using PrISM™ software, as per Environment Agency guidance (Ref. 19.230). This will also ensure that the soundfield will be confined to the immediate area of the intake head, avoiding the risk of any acoustic disturbance in the wider estuarine environment.

19.8.33 AFD underwater sound frequencies will be in the 20-500Hz hearing-sensitive range of most fish (Refs. 19.233, 19.234 and 19.235). Clusters of sound projectors may be deployed on vertical rails or piles, allowing them to be raised above water level periodically for replacement and servicing. Additional sound projectors would be installed to provide a level of redundancy which will allow for any sound projector failures between service events. The condition and sound output status of the AFD

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system would be continuously monitored and logged remotely via an offshore telemetry link.

19.8.34 Performance data for AFDs are summarised by Ref. 19.230 and include data for estuarine and coastal power stations. AFD efficiency values taken from this source are shown in **Table 19.34** for key fish species found at Hinkley Point. Figures range from 0.95 (95%) for sensitive clupeids to 0.16 (16%) for insensitive flatfish. In all cases, these efficiency values were obtained from trials at power stations such as Hartlepool and Doel (Belgium) that do not benefit from having low-velocity intake designs, so improvements would be expected where lower velocities allow more fish to escape.

19.8.35 In practice the design and establishment of a system such as an offshore AFD deployment is a complex procedure involving a degree of uncertainty, requiring appropriate management. Both the necessary design tools (the underwater acoustic modelling capability coupled to a detailed understanding of fish behaviour) and the technology (the sound projectors) are readily available. A technical working group has been established within EDF in order to evolve the initial conceptual design towards the final installation and the outputs from this group will be discussed with the regulators involved as that effort progresses.

19.8.36 Any such system will require commissioning, and experience to date suggests that this commissioning process allied with appropriately designed trials is a key step to securing the required standard of performance

Fish Recovery and Return System

19.8.37 Drum screens within the onshore cooling water pumphouse area are designed primarily to exclude debris that might clog the steam condensers within the turbine hall. The drum screen system selected for HPC is suitable for FRR and will follow or improve upon the detailed Environment Agency guidance on FRR system design. In particular, it will include the following features:

- smooth-finish 5mm drum screen mesh;
- fish bucket design suitable for retention of eel, lamprey and other fish and crustacean species;
- continuous screen rotation at an elevation rate at least 1.5m per minute;
- low- (<1 bar) followed by high-pressure (usually >3 bar) backwash sprays;
- hopper geometry to minimise the risk of fish recycling within the screenwell; and
- smooth-finish troughs with horizontal and vertical bend radius ≥3m.

19.8.38 After considering various options, including a variety of cross-shore routes and return via the main cooling water outfall tunnel, the chosen route for fish return to the subtidal estuary will be via a dedicated bored tunnel driven from landward, under the seawall and intertidal shore, to a specific point on the tidally scoured rock exposure below LAT but above the subtidal muddy plain. In selecting this position there has been a need to balance a series of requirements, not least that the relatively small outfall structure does not become clogged due to progressive siltation with relative sea level rise over the design life of HPC.

19.8.39 A number of additional factors have been taken into account (Ref. 19.236) including:

- the need for an exit point that will permit a discharge line and outfall design that will not entrain solids from seaward, or block over periods of outage;
- the need for a location that will be sustainable over the life of the site, given trends in relative sea level and possible landward encroachment of the subtidal muddy plain;
- the length of the discharge tunnel;
- the risk of re-impingement of discharged fish by the HPB intake;
- avoidance of the HPB thermal plume; and
- potential predation by sea birds, fish or marine mammals.

19.8.40 The fish return tunnel will discharge continuously at a point approximately 550m offshore, some 150m beyond and 1m below the LAT mark, as shown on **Figure 19.37**.

19.8.41 Ref. 19.236 estimates <1% risk of fish re-entering a cooling water intake on a single ebb-flood tide. A relatively short simulation was used as it was considered that animals which survived any longer will have responded and will start to exhibit their own behaviour; animals not exhibiting near normal behaviour within this time are likely to have been predated.

19.8.42 Ref. 19.236 also considered the effect on migratory fish that are drawn in from an intake point 3km offshore and discharged further inshore, showing that fish discharged from the release point quickly re-disperse offshore.

19.8.43 Ref. 19.230 gives typical survival rates for FRR systems ranging from <10% for delicate pelagic species such as herring, sprat and smelt, to between 50 and 80% for demersal species such as cod, whiting and gurnards and >80% for epibenthic fish such as flatfish, gobies, rocklings and crustacean. Lampreys and eels would also fit into this last category, whereas shads would fall into the pelagic group. The values given assume that screens are fitted with FRR fish buckets, low-pressure fish backwash sprays in advance of the high pressure backwash units and are rotated continuously, in line with EA guidance. These values are incorporated within **Table 19.35** below.

19.8.44 Ref. 19.230 advises against addition of biocides upstream of the fish return point or in the fish return water supply, to preclude the potential toxicity risk. Otherwise, where biocides need to be used for operational reasons, a toxicity risk assessment would need to be carried out to ensure that the fish being returned will not be subjected to acute or sublethal toxic risk. It is not envisaged that biocides will be used routinely at HPC but should the need arise, their use will be managed in order to prevent toxic impact within the FRR itself.

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19.8.45 In addition to the main cooling water system drum screens, band-screens will be also be installed in the cooling water pumping station to screen the auxiliary cooling supply. Although these band screens will put materials to the FRR, the likelihood is that the condition of any returned fish or shrimp by that route will not be as high as via the drum screens. Against a total volume flow of approximately $125m^3.sec^{-1}$, these band screens would be responsible for screening no more than $12m^3.sec^{-1}$.

Combined Effect of Intake Mitigation Measures

19.8.46 **Table 19.35** lists the factors used in calculating mitigation performance. Where mitigation factors are not given in Environment Agency guidance, they have been taken from other referenced studies, or values from the nearest similar species (e.g. blue whiting based on whiting, plaice based on flounder values). In the case of FRR mitigation factors, survival rates given in Environment Agency guidance as "<10%" or ">90%" have been allocated mitigation factors of zero and 90% respectively; where, for demersal fish, these have been given a range of survival values of between 50 and 80%, a mitigation factor of 0.5-0.8 has been used. The HPC low velocity side entry intake (LVSE) mitigation factors are taken from Ref. 19.43.

Table 19.35: Assumed Proportional Effects of Intake System Mitigations (Mitigation Factors)

Species	AFD Efficiency F_{AFD}	Catch Reduction with Low Velocity Side Entry (LVSE) Intake F_{LVI}	Survival through FRR F_{FRR}
Sprat (largest numbers)	0.88	0.34	0.00
Whiting (BAP)	0.55	0.49	0.50 -0.80
Sole (BAP)	0.16	0.36	0.80
Cod (BAP)	0.55	0.51	0.50 -0.80
Herring (BAP)	0.95	0.34	0.00
Plaice* (BAP)	0.16	0.76	0.80
Blue whiting* (BAP)	0.55	0.49	0.50 -0.80
Eel (Eel management plan)	0.16	1	0.80
Twaite shad* (SAC designated)	0.88	0.383	0.00
Allis shad* (SAC designated)	0.88	0.383	0.00
Sea lamprey* (SAC designated)	0.06	1	0.80
River lamprey** (SAC designated)	0.06	1	0.80
Salmon (SAC designated)	n/a	n/a	n/a
Crangon	0.00	1	0.80

19.8.47 The order in which the mitigation factors are applied is important. The AFD is the first mitigation experienced by approaching fish (crustaceans are assumed not to be sensitive to the AFD) and this factor is therefore applied first. The effect of reduced velocity is then applied to reduce the number of fish entering the intake. Finally, the mitigation factor for survival rate in the FRR system is applied to give an overall estimate of losses associated with cooling water abstraction.

19.8.48 The AFD and FRR mitigation factors described in **Table 19.34** have been incorporated in the assessments that follow and, in aggregate, describe the minimum performance standard that the operator would expect to meet through implementation of these measures at HPC.

19.9 Residual Impacts

a) Introduction

19.9.1 Following implementation of the proposed mitigation and management measures, impacts have been re-assessed, where appropriate, to determine the residual impact. These are outlined below for each of the described impacts.

b) Construction

i. Habitat Loss and Change

19.9.2 Following implementation of the proposed mitigation measures above, the impacts of physical construction in terms of habitat loss will be reduced to a very low magnitude, with a **minor adverse** residual impact remaining where sensitivity (most obviously in terms of the *Corallina* swards) is high.

ii. Physical Disturbance

19.9.3 The impacts associated with physical disturbance to marine ecology, following the implementation of mitigation measures, will be constrained to **minor adverse** significance.

iii. Changes in Water Quality

19.9.4 Following mitigation measures outlined above, the residual impacts of construction and commissioning discharges on local marine ecological interests will be constrained to a **minor adverse** level of significance, with a low magnitude and extent affecting only habitats of low sensitivity,

iv. Noise

19.9.5 The residual impact of underwater noise on sensitive receptors during construction, following the implementation of mitigation measures, will be constrained to one of **minor adverse** significance.

v. Artificial Lighting

19.9.6 **No impacts** to marine ecology were identified during construction from artificial lighting and, therefore, the residual impact is unchanged.

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c) Operation

i. Chemical Discharges

19.9.7 On the basis that appropriate limits may be set on any application of a dosing regime, by constraining the magnitude of the impact to low whilst retaining the understanding of medium sensitivity, the residual significance of the impact concerned will reduce from moderate to **minor adverse**.

ii. Impingement of Fish and Shrimp

19.9.8 **Table 19.36** summarises estimates of fish and crustacean losses attributable to HPB and HPC cooling water abstraction for the key commercial and conservation species and for shrimps. Predicted entrainment rates (**Table 19.33**) are considered to be too small in relation to Bristol Channel stocks to merit further consideration.

19.9.9 The great majority of fish caught at Hinkley Point are juveniles. This assessment thus depends upon a calculation of Adult Equivalent Value (EAV) based upon known fisheries-related or conservation-related estimates of population and age structure in order to scale the level of impact involved.

Table 19.36: Predicted Total Annual Impingement (numbers of fish, EAV) at HPC and HPB for Selected Species assuming an Abstraction Rate of 125m^3.s^{-1} via Current Intake Structures and via Low-Velocity Side Entry (LVSE) Intake Structures with AFD and with a FRR System (data from Ref. 19.43)

Species: Common Name	HPC, Current (HPB) Intake Design	HPB	HPC with Low-Velocity Intake and AFD (increase from current HPB)		HPC with Low-Velocity Intake and AFD and FRR (increase from current HPB)	
Sprat (largest numbers)	3,380,850	936,386	405,702	-(57%)	405,702	-(57%)
Whiting (BAP)	288,078	79,253	129,635	(64%)	64,818	-(18%)
Sole (BAP)	32,429	8,599	27,241	(218%)	5,448	-(36%)
Cod (BAP)*	32,063	8,733	14,428	(65%)	7,214	-(17%)
Herring (BAP)	44,792	12,570	2,240	-(82%)	2,240	-(82%)
Plaice (BAP)	493	129	414	(221%)	83	-(36%)
Blue whiting (BAP)	160	46	72	(55%)	36	-(22%)
Eel (Eel management plan)	1,304	351	1,304	(272%)	261	-(26%)
Twaite shad (SAC designated)	2,276	646	273	-(58%)	273	-(58%)
Allis shad (SAC designated)	68	22	8	-(63%)	8	-(63%)
Sea lamprey (SAC designated)	207	42	207	(398%)	41	(0%)
River lamprey (SAC designated)	82	18	82	(355%)	16	-(9%)
Salmon (SAC designated)	0	0	0	(0%)	0	(0%)

Species: Common Name	HPC, Current (HPB) Intake Design	HPB	HPC with Low-Velocity Intake and AFD (increase from current HPB)		HPC with Low-Velocity Intake and AFD and FRR (increase from current HPB)	
Sea trout (SAC designated)	0	0	0	(0%)	0	(0%)
Brown shrimp (*Crangon crangon* – the main crustacean impinged	19,135,756	4,911,592	19,135,756	(290%)	3,827,151	-(22%)

* *Cod assessment has subsequently been reappraised to account for bias caused by an exceptional spike in recruitment during the period of sampling upon which this original assessment was based, in 2009; the ratio of annual catches 2008:2009 was 5.8% and that for the mean of 2004-2008:2009 was 7.3% (Ref. 19.260).*

Sprat

19.9.10 With the AFD and LVSE intake design, the numbers of adult sprat impinged annually at HPC could be reduced to approximately 3.16t, which is about 17 times the local fishery. Sprat are delicate bodied species and as a result the FRR system is unlikely to reduce impingement mortality. With mitigation, the residual impact of cooling water abstraction on sprat populations is considered to be **minor adverse**.

Whiting

19.9.11 With the Acoustic Fish Deterrence (AFD) and low velocity side entry (LVSE) intake design, the reduction in annual impingement numbers of whiting is reduced to approximately 23t and 1.4% of the local standing stock biomass (SSB). The Fish Recovery and Return (FRR) system is expected to reduce mortality of this species by 50% and as a result the post- -mitigation residual impact is considered to be **minor adverse**.

Sole

19.9.12 The mitigation measures discussed above are likely to reduce annual impingement numbers to 6.24t, as a demersal species the FRR system could reduce impingement by about 96% (Ref. 19.241), but using a more conservative figure of 80% the residual impact would be reduced to **minor adverse**.

Cod

19.9.13 Under the current assessment, based on CIMP data in 2009-10, AFD and the LVSE intake design could reduce impingement numbers of this species to approximately 63.1t which is about 6.48% of the local SSB. As a demersal species the FRR could reduce impingement mortality by about 94% (Ref. 19.241). However, the cod assessment has recently been reappraised to account for bias caused by an exceptional spike in recruitment during that particular period of sampling. The ratio of annual catches at HPB over 2008:2009 was 5.8% and that for the mean of 2004-2008:2009 was 7.3% (Ref. 19.260). Thus, on a worst case basis, the HPC catch prior to mitigation would be 0.24% of the local SSB. As a result, with mitigation, the magnitude of impact is estimated as very low. In combination with a receptor value/sensitivity of moderate this suggests an impact of **minor adverse** significance.

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Herring

19.9.14 The AFD and low velocity intake is likely to reduce impingement mortality of herring by approximately 0.24t equating to about 0.24% of the local fishery, the FRR is unlikely to bring any benefit to this delicate bodied species. Taking into the consideration the AFD and LVSE mitigation measures the residual impact on this species post-mitigation is considered to be **minor adverse**.

Plaice

19.9.15 Equivalent adult numbers of plaice impinged annually at HPC could be reduced to around 00.19t with the use of AFDs and the low velocity intake, with the FRR impingement mortality could be reduced by a further 80%, the residual impact on this species is therefore considered to be **minor adverse**.

Blue whiting

19.9.16 With the AFD, the EAV of blue whiting is reduced to 72 fish equating to <0.1% of the blue whiting fishery. Due to a lack of information on the swimming speed of this species it is not possible to assess the impact of the low velocity intake. Assuming the effectiveness of the FRR is similar to whiting, a very similar species, the FRR could reduce impingement mortality by up to 50%, meaning the post-mitigation residual impact is assessed to be **minor adverse**.

Eel

19.9.17 Eels are unlikely to benefit from the low velocity intake, however they are considered to be a robust fish and the FRR could reduce impingement mortality by up to 100%. Assuming a more conservative estimate of 80%, the residual impact on this species post-mitigation is **minor adverse**.

Shad

19.9.18 The AFD and LVSE intake design impingement mortality of twaite shad could be reduced to approximately 273 fish, about 0.15% of the local estimated population. As a delicate bodied species similar to herring and sprat, the FRR is unlikely to reduce impingement mortality further and the post-mitigation residual impact is expected to be **minor adverse**.

Lamprey

19.9.19 Lamprey are unlikely to benefit from the AFDs and low velocity intake design, however they are considered to be a robust fish and a suitable FRR could reduce impingement mortality by up to 100%. Assuming a more conservative estimate of 80%, the residual impact on lamprey post-mitigation is considered to be **minor adverse**.

Shrimp Populations

19.9.20 Impingement rates of C. crangon at HPB are very high. It is known that *C. crangon* feed on the intertidal mudflats at high tide. As the tide recedes they migrate to the shallow subtidal and are found in a concentrated band in the shallow subtidal

(Ref. 19.102). Thus, the natural behaviour of *C. crangon* is likely to concentrate it in the vicinity of the intake structure at certain times. Other intertidal mudflat will be found much further away from the intake. The HPC intake structures are also being constructed further offshore than those at HPB. Overall the magnitude of the impact has been assessed as medium.

19.9.21 Even though *C. crangon* cannot actively avoid entrainment and impingement, the literature suggests that the larvae will have high survival rates following entrainment. (Ref. 19.240). Impingement rates of *C. crangon* are predicted to be reduced with the use of FRR.

19.9.22 Such species are both highly fecund and mobile so recolonisation rates following disturbance are typically rapid. Recent data suggests that numbers observed via SEDS at HPB have been increasing which suggests the current abstraction activities are not affecting the mudflat communities (Ref. 19.102). These understandings suggest a high degree of resilience. Sensitivity is thus considered to be very low.

19.9.23 With low sensitivity and medium magnitude of impact, a **minor adverse** impact is predicted.

Fish Assemblage

19.9.24 The proposed HPC has been specified with low velocity side-entry (LVSE) intake structures and a Fish Recovery and Return system. If these proposed impingement mitigation measures function as designed, the impingement losses at HPC are calculated to be similar to those of the existing HPB.

19.9.25 The resulting HPC impingement losses will have a negligible effect on the spawning stock of the protected migratory species that use the Severn Estuary and have been captured on the intake screens of HPB (European eel, sea lamprey and twaite shad). The catches of Allis shad and salmon on the HPB intake screens are too small to allow a reliable impingement loss to be calculated.

19.9.26 The impact on the commercially important fish species that represent the majority of the existing impingement losses (sprat, whiting, sole, plaice, herring and blue whiting) is considered to be negligible. For whiting, sole, plaice and blue whiting the impingement losses will have a negligible effect on the spawning stock. Sprat is the dominant (>97%) clupeiform fish impinged at HPB and the population trend for this group since 1981 has remained stable. As HPC (with mitigation) will only impinge 28% more that the current HPB, the conclusion is that HPC (with mitigation) is unlikely to have any significant impact on local sprat population.

19.9.27 For herring the impingement losses are less than 2% of the local fishery and will therefore have negligible impact on the local population.

19.9.28 The impact on cod will represent 0.24% of the local SSB (Ref. 19.260). This level of loss is equivalent to 0.06% of the Total Allowable Catch of cod recommended by ICES for 2011 for Divisions VIIe-k (3,420t) and is unlikely to have any detectable effect on the local cod population when considered against the background natural variability in SSB. The predicted losses of cod from a mitigated HPC are 12%

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greater than those currently caused by HPB. HPB has had no measurable effect on the local abundance trend for cod since 1981.

19.9.29 The predicted impingement losses on crustaceans (as represented by the impact on the brown shrimp *C. crangon* the main crustacean impinged) are also expected to be similar to those of HPB.

19.9.30 On the basis that impacts on all species examined above are predicted to be minor, and that these species provide a reasonable cross section of the local fish assemblage as a whole, the residual impact on the fish assemblage as a whole as a result of HPC operations is also assessed as **minor adverse**.

iii. Entrainment

19.9.31 Predicted entrainment rates (**Table 19.31**) are considered to be too small in relation to Bristol Channel stocks to merit further consideration. The residual impact following the implemented of mitigation is assessed as **minor adverse**.

19.10 Proposed Monitoring Measures

a) Introduction

19.10.1 Monitoring will be undertaken to inform the need for adjustment to the mitigation measures applied and check the continuing validity of assumptions.

19.10.2 The listing below is indicative; detailed surveillance and allied contingency protocols will be subject to further development.

b) Technical Review Procedure

19.10.3 In consultation with the relevant regulatory bodies EDF Energy will establish and maintain a technical working group to:

- maintain active stewardship of the objectives involved in the monitoring described both above and described in **Volume 2**, **Chapters 18** and **19**;
- advise upon the appropriate level of detail of these efforts, and
- review outcomes, advising on any necessary consequent action.

19.10.4 The technical working group will be made up of a number of recognised technical specialists, an independent chairman, and be supported by a secretariat, all operating under agreed Terms of Reference. An interface with regulatory technical nominees will be maintained throughout and their active involvement as observers of the technical review process encouraged.

19.10.5 The group will report to EDF Energy. It is envisaged that this technical review procedure will continue to operate throughout the period of HPC construction and into the early years of generation.

c) Construction

i. Corallina run-offs

19.10.6 Considerable care will be required in order not to compromise the cross-shore rock platform physics of the habitat upon which the *Corallina* run-offs depend. Thus, as stated within **Volume 2 Chapter 17**, to guard against untoward effects on the longshore drainage regime and the sensitive habitats associated with these, monitoring will assess both the establishment of the remedial measures involved and the longer term consequence of these activities.

ii. Cetaceans and Noise

19.10.7 Although the numbers would appear to be low, especially close to the site itself, recent evidence from acoustic monitoring in the Hinkley Point area contradicts previous assumptions that small cetacea do not frequent the area.

19.10.8 Acoustic monitoring will thus be continued both to secure the local baseline and, subsequently, to test for the relative presence or absence of small cetacea over the periods of construction when significant noise disturbance (from percussive piling) is likely. The acoustic array will not be maintained beyond the construction period.

19.10.9 Expert advice will be obtained on whether or not, with the acoustic monitoring network already in place, and data on seasonal and spatial distribution available, any further measures will be necessary to manage these works through active surveillance of cetacean presence, as implied by current guidance (Ref. 19.155).

iii. Discharge to Intertidal Area

19.10.10 All construction and some commissioning discharges will be put to a single cross-shore discharge. Although hydraulic modelling has shown that this combined discharge will be constrained both in terms of route and width and that the impacts are predicted to be minor, these understandings will be confirmed through periodic monitoring of the intertidal area involved.

iv. Scour

19.10.11 A limited degree of seabed scour will be associated with the offshore components of the temporary aggregate jetty, the cooling water intake structures, the cooling water outfall structures, and the discharges arising from these latter structures. Likewise, there is the possibility of linear bathymetric features developing in association with the jetty berthing pocket.

19.10.12 The aerial extent of scour associated with these structures and features will be monitored by sidescan and swathe sonar survey following station commissioning, and the need to revisit this effort reviewed on the basis of initial findings. Associated ground truthing (grab sampling) will permit mapping of the resultant habitat and biotope distributions in the immediate vicinity will be appropriate.

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d) Operation

i. Numerical Modelling

19.10.13 There has inevitably been is a very considerable dependency, within the assessment developed both in this Chapter and **Volume 2**, **Chapter 18**, upon the outputs of numerical hydrodynamic models.

19.10.14 Whilst the primary hydrodynamic models have been subject to considerable challenge over the course of their development, and as a fully validated and calibrated ensemble represent current best practice in terms of constraining uncertainty, they are nonetheless estimates of reality rather than observations.

19.10.15 As a result, and in accord with Environment Agency guidance for NNB (Ref. 19.68), it will be appropriate to conduct field investigations in two circumstances: when a single EPR unit is fully operational and once both units are operating together. The standard for such investigations is set by Ref. 19.20 and 19.68. This monitoring will capture the behaviour of the thermal plumes under known tidal and meteorological conditions, allowing comparison of the results with previous estimates. Additional model runs may prove necessary in order to replicate the field conditions found at the time.

19.10.16 There will be a need to gather a sufficient body of empirical data on these operations before it becomes possible to validate certain of these models. Until that point only observational data will be available.

19.10.17 **Appendix 18A** to **Chapter 18** describes the development of the existing numerical hydrodynamic models and the extent of compliance with current Environment Agency guidance appropriate to considerations of New Nuclear Build in the UK (Ref. 19.68), That guidance also requires that the models will continue to be 'available for use over the period of at least 10 years from the date of commissioning of the power station, and beyond that for as long as there is (are) no suitable alternative)s) available'.

ii. Efficacy of Fish Protection Measures

Acoustic Fish Deterrence (AFD)

19.10.18 Precautionary estimates have been used is assessing the mitigaiton benefit of the acoustic fish deterrent (AFD) systems that will be deployed around the HPC cooling water intakes.

19.10.19 There will be a need to prove that the minimum performance standard, based upon these estimates, has been met early in the operational life of the station. Thus, trials defined by current guidance on best practice (Ref. 19.19) will be carried out at that time and any adjustments made to the AFD systems and the trials then extended system should this prove necessary.

19.10.20 Such trials would carried out over a period of weeks or a few months and involve the enumeration and identification of fish impinged on the CW screens. Over this period the AFD systems would be switched on and off on alternate days. The trials would cease only once specific statistical criteria on the difference between ‘AFD on’ and ‘AFD off’ days, for a range of species, have been met.

19.10.21 The nature of the AFD deployment, as a series of active instrument packages requiring routine maintenance, means that instrumented monitoring of the performance of this equipment would be needed for the life of the plant, coupled with a routine maintenance cycle. Once initial proving trials have been secured, this requirement would be limited to confirming the appropriate underwater sound field is being maintained via telemetry from the offshore instrument packages themselves. If any unexpected deterioration is observed that might hazard the minimum performance standard, this would bring forward the maintenance cycle on the AFD system involved.

Low Velocity Side Entry (LVSE) Intake Design and Position

19.10.22 The HPC intake design is novel, although with a strong basis of understanding from both previous trials, numerical modelling studies, and expert advice. The intakes are also, following advice on best practice for fish protection (Refs. 19.229 and 19.230), located well offshore.

19.10.23 In practice, given the fixed nature of the installations, it will not be possible to discriminate the actual benefits of the HPC LVSE intake design from any benefit of offshore location, but the sum of that benefit may become apparent through maintaining fish impingement monitoring of the HPB drum screens over the period of the AFD trials described above, both on ‘AFD on’ and ‘AFD of’ days, either for their full duration or until specific statistical criteria are met.

Fish Recovery and Return (FRR) Efficacy

19.10.24 As with the AFD, a precautionary estimate of system efficacy has been incorporated in the assessments mentioned earlier in this chapter.

19.10.25 There will be a need to prove that the minimum performance standard, based upon these estimates, has been met early in the operational life of the station. Thus trials defined by current guidance on best practice (Ref. 19.19) and based on previous experience (Ref. 19.207 and 19.241) will be carried out at that time and any adjustments then made to the system in order to secure that standard, should this prove necessary.

iii. Fish Monitoring Programme

19.10.26 A fish impingement/entrainment programme will be developed and implemented, using best practice developed through BEEMS and elsewhere. This will include tests of the AFD system, such as those described above, to define the benefits of both the AFD system itself and the LVSE intake design and location against the HPB base, should HPB still be operating. This will inform enhanced operation of the AFD and FRR systems as necessary as well as informing sustainable decision making at other sites.

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19.10.27 The comprehensive impingement monitoring programme (CIMP), utilised to estimate likely impingement catches of HPC for this ES, will be re-established for a single annual period at HPC in order to confirm these previous estimates.

iv. Chlorination

19.10.28 The primary means of constraining the operational need to control biological fouling through oxidant dosing is via continuing surveillance both of local intertidal shores and for the presence of epifaunal growth within the cooling water circuits themselves.

19.10.29 Such surveillance is currently maintained by HPB and elements of this, adapted as appropriate given the difference in plant design (primarily the offshore position and low flow nature of the HPC intake design), will be adopted by the HPC operator.

v. Trends and Variance in Local Populations

19.10.30 There will be an advantage both to the operator and others in furthering medium to long-term so as to maintain an understanding of key populations.

Invertebrate Populations on Stert Flats

19.10.31 The existing baseline of seasonal studies of *Macoma* and other key invertebrate species on Stert Flats will be extended in order to elaborate on the existing understanding of within-year and between-years variance. After an initial three year period a reduced sampling strategy will be implemented in order to track longer term trends in these populations.

vi. Severn Estuary Data Set (SEDS)

19.10.32 By the end of 2011 there will be a time series of fish impingement data based upon 31 years of continuous monthly sampling at Hinkley Point.

19.10.33 This database was instigated within the CEGB with an understanding that only with the establishment of at least one such long-term database in the UK would the scientific community and plant operators be able to describe the baseline of longer term change against which developments such as HPC might best be understood.

19.10.34 Although the use of fish protection measures at HPC, which in combination will reduce the catch per unit volume to one a third of that experienced at HPB, will mean that a like for like continuation of this exercise on the new station will not strictly be possible, there will be considerable value in continuing such sampling for the longer term. The implementation of the CIMP programme described above will, should the two stations operate in parallel, will provide a means of calibration between the different station catch rates.

19.11 Summary of Impacts

a) Introduction

19.11.1 Impacts have been assessed after taking into consideration aspects of project design and management and generic mitigation measures which would be required as part of the development. Following this approach the vast majority of impacts have been predicted to be of negligible to minor significance, although some are considered to be of moderate significance before mitigation. In these instances specific mitigation has been identified, as discussed in the previous sections of this Chapter. The predicted residual effects as they stand are presented in **Table 19.37** and **Table 19.38** below.

b) Construction

19.11.2 A summary of the potential impacts on marine ecology associated with the construction of HPC, setting out impacts prior to mitigation, the mitigation proposed, and the subsequent residual impacts is presented in **Table 19.37**.

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Table 19.37: Assessed Impacts of Significance during the Construction Phase

Sensitivity	Significance Pre-mitigation	Reason	Mitigation	Residual Significance
Habitat Loss and Change				
Intertidal habitats: general	Minor	Jetty construction and removal	Best practice in managing works on the shore	Minor
Corallina biotope	Minor	Jetty construction and removal	Best practice in managing works on the shore	Minor
Intertidal habitats	No Impact	Seawall construction	Best practice in managing works on the shore	No Impact
Subtidal habitats	Negligible	Vertical cooling water shaft construction	Best practice in managing works offshore	Negligible
Subtidal fauna	Negligible	Vertical cooling water shaft construction	Best practice in managing works offshore	Negligible
Sabellaria reef	No Impact	Vertical cooling water shaft construction	Best practice in managing works offshore	No Impact
Subtidal habitats	Minor	Capital and maintenance dredging	Best practice in managing works offshore	Minor
Physical Disturbance				
Intertidal habitats	Minor	Jetty construction and removal	Best practice in managing works on the shore	Minor
Intertidal habitats	Minor	Sea wall construction	Restricted working corridor; best practice in managing works on the shore	Minor
Intertidal habitats	Moderate	Barge delivery of rock armour to shore	Restricted landing area	Minor
Sabellaria reef	No impact	Jetty construction and removal	Jetty alignment is remote from reef areas	No impact
Corallina biotope	Minor	Due to pile driving activity and plant movement on the intertidal	Best practice in managing works on the shore (constrained corridor, avoidance of compaction of surface) coupled with restoration of microtopography	Minor

Sensitivity	Significance Pre-mitigation	Reason	Mitigation	Residual Significance
Subtidal habitats	Negligible	Scour allied with jetty piers	Impacts are highly localised with very limited ecological consequence	Negligible
Intertidal habitats	Minor	Introduction of waste materials and particulates from seawall construction	Best practice in managing works on the shore	Minor
Seawall: *Corallina* biotope	No impact	Introduction of waste materials and particulates from seawall construction	Best practice in managing works on the shore; seawall is remote from Corallina run-off areas	No impact
Subtidal habitats	Negligible	Vertical cooling water shaft construction	Best practice in managing works offshore	Negligible
Subtidal habitats – suspended sediments	Negligible	Vertical cooling water shaft construction	Best practice in managing works offshore	Negligible
Subtidal habitats	Minor	Capital and maintenance dredging	Best practice in managing works offshore	Minor
Changes in Water Quality				
Subtidal habitats	Negligible	Capital and maintenance dredging	Best practice in managing works offshore	Negligible
Corallina biotope	Negligible	Capital and maintenance dredging	Isolated due to tidal regime	Negligible
Sabellaria reef	Negligible	Capital and maintenance dredging	Best practice in managing works offshore	Minor
Subtidal habitats	Negligible	Vertical cooling water shaft construction	Best practice in managing works offshore	Negligible
Corallina biotope	Minor	Construction site discharges: composition	Appropriate discharge location selected on basis of intertidal biotope distributions; additional mitigation by effluent treatment	Minor
Sabellaria reef	Minor	Construction site discharges: composition	As above	Minor

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Sensitivity	Significance Pre-mitigation	Reason	Mitigation	Residual Significance
Intertidal habitats	Minor	Construction site discharges: composition	As above	Minor
Intertidal due to sedimentation	Minor	Construction site discharges: scour	Appropriate discharge location selected on basis of intertidal biotope distributions; additional mitigation by effluent treatment	Minor
Intertidal due to salinity changes	Minor	Construction site discharges: variable salinity	As above	Minor
Fish	Minor	Construction site discharges: suspended solids	Best practice in managing works on the shore	Minor
Corallina biotope	Minor	Seawall construction	Best practice in managing works on the shore	Minor
Sabellaria reef	No impact	Seawall construction	Best practice in managing works on the shore	No impact
Fish	No impact	Seawall construction	Best practice in managing works on the shore	No impact
Noise and Vibration				
Fish: hearing generalist minus swim bladder (lampreys, dab, sole, plaice)	Negligible	Percussive pile driving generating underwater noise which can cause avoidance reactions or physical injury to fish	Use of 'soft start' approach to piling	Negligible
Fish: hearing generalist minus swim bladder (lampreys, dab, sole, plaice)	Negligible	Noise and vibration associated with dredging	Best practice in managing works offshore	Negligible
Fish: hearing generalist minus swim bladder (lampreys, dab, sole, plaice)	Minor	Noise and vibration associated with construction of horizontal tunnels	Best practice in managing works offshore	Minor
Fish: hearing generalist plus swim bladder (salmon, sea trout, eel, cod,	Minor	Percussive pile driving generating underwater noise which can cause avoidance reactions	Use of 'soft start' approach to piling	Minor

Sensitivity	Significance Pre-mitigation	Reason	Mitigation	Residual Significance
whiting)		or physical injury to fish		
Fish – hearing specialists (shads, sturgeon, herring, sprat)	Moderate	As above	Use of 'soft start' approach to piling	Minor
Marine mammals	Minor	As above	As above	Minor
Artificial Lighting				
Intertidal habitats	No impact	Lighting on aggregate jetty during construction and/or operation	N/A	No impact
Water column	Negligible	As above, plus offshore construction works for the placement of cooling water headworks	N/A	Negligible

c) Operation

19.11.3 A summary of the potential impacts on marine ecology associated with the operation of HPC, setting out impacts prior to mitigation, the mitigation proposed, and the subsequent residual impacts is presented in **Table 19.38**.

Table 19.38: Assessed Impacts of Significance during the Operational Phase

	Significance Pre-mitigation	Reason	Mitigation	Residual Significance
Thermal Discharges				
Non-migratory fish	Minor	Thermal regime change	Majority are tolerant to temperature variations	Minor
Migratory fish	Minor	Thermal regime change plus thermal occlusion of migratory pathways	Selected intake/outfall configuration	Minor
Benthic habitats: *Corallina* biotope and *Sabellaria* reef	No impact	Intersection of thermal plume with intertidal and shallow subtidal areas	As above	No impact
Benthic habitats: *Macoma balthica*	Minor	As above	As above	Minor

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	Significance Pre-mitigation	Reason	Mitigation	Residual Significance
Benthic habitats: ecological functioning on Stert Flats	Minor	As above	As above	Minor
Benthic habitats: subtidal	Minor	Intersection of plume with subtidal areas	As above	Minor
Microphytobenthos	No impact	Intersection of thermal plume with intertidal areas	As above	No impact
Crangon crangon population	Negligible	Thermal plume	As above	Negligible
Adequacy of intertidal invertebrate prey resource to avifauna	Minor	Intersection of thermal plume with intertidal areas	As above	Minor
Chemical Discharges				
Intertidal habitats: *Corallina* biotope and *Sabellaria* reef	Moderate	Commissioning waste streams via cross-shore discharge	Appropriate positioning of discharge location. Effluent sentencing and pre-treatment	Minor
Subtidal habitats	Minor	Commissioning waste streams via cooling water system outfall	Effluent sentencing and pre-treatment	Negligible
Chlorine EQS (acute)	Minor	Operational discharge of residual biocide	Selected intake/outfall configuration	Minor
Site specific Screening Level (chronic)	Moderate	Operational discharge of residual biocide	Selected intake/outfall configuration. Constrained dosing regime	Minor
Chlorination by-products	Minor	Operational discharge of residual biocide	Selected intake/outfall configuration. Constrained dosing regime	Minor
Subtidal habitats and water column immediately around outfall headworks	Minor	Operational discharge of hydrazine	Hydrazine discharges will be constrained	Minor
Subtidal habitats and water column immediately around outfall headworks	Negligible	Operational discharge of morpholine	Low toxicity	Negligible
Subtidal habitats and water column immediately around outfall headworks	No impact	Operational discharge of ethanolamine	Low toxicity	No impact

	Significance Pre-mitigation	Reason	Mitigation	Residual Significance
Trophic functioning	Negligible	Operational discharge of nitrogen and phosphorous	Very low volumes to be discharged	Negligible
Subtidal habitats and water column immediately around outfall headworks	Negligible	Operational discharge of ammonia	Very low volumes to be discharged	Negligible
Impingement of Fish and Shrimp				
Sprat	Moderate	Population mortality	AFD + low velocity intake design	Minor
Whiting	Moderate	Population mortality	AFD + low velocity intake design + FRR	Minor
Sole	Minor	Population mortality	FRR	Minor
Cod	Minor	Population mortality	AFD + low velocity intake design + FRR	Minor
Plaice	Minor	Population mortality	FRR	Minor
Blue whiting	Minor	Population mortality	AFD + low velocity intake design + FRR	Minor
Sea bass	Minor	Population mortality	AFD + low velocity intake design + FRR	Minor
Crustaceans incl. *Crangon crangon*	Moderate	Population mortality	FRR	Minor
Salmon	Negligible	Population mortality	AFD + low velocity intake design + FRR	Negligible
Twaite shad	Moderate	Population mortality	AFD + low velocity intake design + FRR	Minor
Eel	Moderate	Population mortality	FRR	Minor
River and sea lamprey	Moderate	Population mortality	FRR	Minor
Fish assemblage	Moderate	Population mortality; functioning	AFD + low velocity intake design + FRR	Minor
Entrainment				
Ichthyoplankton	Minor	Population mortality	5mm mesh limits entrainment forcing diversion to FRR	Minor

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	Significance Pre-mitigation	Reason	Mitigation	Residual Significance
Other zooplankton including mysids	Minor	Population mortality; functioning	5mm mesh limits entrainment forcing diversion to FRR	Minor
Phytoplankton	Minor	Population mortality; functioning	5mm mesh limits entrainment forcing diversion to FRR	Minor

Notes: AFD: Acoustic Fish Deterrence System; FRR: Fish Recovery and Return System

19.12 Conclusions

19.12.1 An extensive series of marine ecological studies, calling upon longer term efforts and project-specific investigations, has secured a good understanding of the marine environment local to the Hinkley Point site.

19.12.2 Early design considerations carried out using numerical modelling tools developed on the basis of these marine studies have enabled the consideration of a variety of cooling water intake and outfall configurations. Subsequently, these same studies have been utilised in optimising finer detail of the cooling water system designs, leading to a series of means of mitigating potentially untoward impacts, as described above.

19.12.3 In summary, with appropriate design and management of HPC construction and operation, all impacts upon marine ecological receptors can be rendered limited to no greater than minor adverse significance.

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