Annex I

Appropriate Assessment Report for Aquaculture in Bannow Bay SAC

(Site code: 000697)

Version: November 2017

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 PREFACE

In Ireland, the implementation of Article 6 of the Habitats Directive in relation to aquaculture and fishing projects and plans that occur within designated sites is achieved through sub-Article 6(3) of the Directive. Fisheries not coming under the scope of Article 6.3, i.e. those fisheries not subject to secondary licencing are subject to risk assessment. Identified risks to designated features can then be mitigated and deterioration of such features can be avoided as envisaged by sub-article 6.2.

Fisheries, other than oyster fisheries, and aquaculture activities are licenced by the Department of Agriculture, Food and Marine (DAFM). Oyster fisheries (in fishery order areas) are licenced by the Department of Communications Energy and Natural Resources (DCENR). The Habitats Directive is transposed in Ireland in the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. 477 of 2011). Appropriate assessments (AA) of aquaculture and risk assessments (RA) of fishing activities are carried out against the conservation objectives (COs), and more specifically on the version of the COs that are available at the time of the Assessment, for designated ecological features, within the site, as defined by the National Parks and Wildlife Service (NPWS). NPWS are the competent authority for the management of Natura 2000 sites in Ireland. Obviously, aquaculture and fishing operations existed in coastal areas prior to the designation of such areas under the Directives. Ireland is thereby assessing both existing and proposed aquaculture and fishing activities in such sites. This is an incremental process, as agreed with the EU Commission in 2009, and will eventually cover all fishing and aquaculture activities in all Natura 2000 sites.

The process of identifying existing and proposed activities and submitting these for assessment is, in the case of fisheries projects and plans, outlined in S.I. 290 of 2013. Fisheries projects or plans are taken to mean those fisheries that are subject to annual secondary licencing or authorization. Here, the industry or the Minister may bring forward fishing proposals or plans which become subject to assessment. These Fishery Natura Plans (FNPs) may simply be descriptions of existing activities or may also include modifications to activities that mitigate, prior to the assessment, perceived effects to the ecology of a designated feature in the site. In the case of other fisheries, that are not projects or plans, data on activity are collated and subject to a risk assessment against the COs. Oyster fisheries, managed by DCENR, do not come under the remit of S.I. 290 of 2013 but are defined as projects or plans as they are authorized annually and are therefore should be subject to AA.

In the case of aquaculture, DAFM receives applications to undertake such activity and submits a set of applications, at a defined point in time, for assessment. The FNPs and aquaculture applications are then subject to AA. If the AA or the RA process finds that the possibility of significant effects cannot be discounted or that there is a likelihood of negative consequence for designated features then such activities will need to be mitigated further if they are to continue. The assessments are not explicit on how this mitigation should be achieved but rather indicate whether mitigation is required or not and what results should be achieved.

2 EXECUTIVE SUMMARY

2.1 THE SAC

Bannow Bay SAC is a large estuarine site, approximately 14km long on the south coast of County Wexford. The bay is designated as a Special Area of Conservation (SAC) under the Habitats Directive. Designated marine habitats include Estuaries (1130) and Mudflats and sand flats not covered by seawater at low tide (1140) each of which support soft sedimentary communities and community complexes. The site also contains, and is designated for, a range of coastal habitats including salt meadow, sand dunes and scrub. Conservation Objectives for marine habitats and constituent communities within Bannow Bay SAC were identified by NPWS (2012a) and relate primarily to the requirement to maintain habitat distribution, structure and function, as defined by characterizing (dominant) species in these habitats. For designated species the objective is to maintain various attributes of the populations including population size, habitats quality and the distribution of the species.

2.2 ACTIVITIES IN THE SAC

Within Bannow Bay SAC aquaculture focuses on the cultivation of the Pacific oyster *Crassostrea gigas* on trestles in intertidal areas of the bay. The profile of the aquaculture industry in the SAC, used in this assessment, was prepared by BIM and is derived from the list of licence applications received by DAFM and provided to the MI for assessment in February 2015.

2.3 THE APPROPRIATE ASSESSMENT PROCESS

The function of an appropriate assessment and risk assessment is to determine if the ongoing and proposed aquaculture activities are consistent with the Conservation Objectives for the Natura site or if such activities will lead to deterioration in the attributes of the habitats and species over time and in relation to the scale, frequency and intensity of the activities. NPWS (2012a) provide guidance on interpretation of the Conservation Objectives which are, in effect, management targets for habitats and species in the SAC. This guidance is scaled relative to the anticipated sensitivity of habitats and species to disturbance by the proposed activities. Some activities are deemed to be wholly inconsistent with long term maintenance of certain sensitive habitats while other habitats can tolerate a range of activities. For the practical purpose of management of sedimentary habitats a 15% threshold of overlap between a disturbing activity and a habitat is given in the NPWS guidance. Below this threshold disturbance is deemed to be non-significant. Disturbance is defined as that which leads to a change in the characterizing species of the habitat (which may also indicate change in structure and function). Such disturbance may be temporary or persistent in the sense that change in characterizing species may recover to pre-disturbed state or may persist and accumulate over time.

The appropriate assessment and risk assessment process is divided into a number of stages consisting of a preliminary risk identification, and subsequent assessment (allied with mitigation measures if necessary) which are covered in this report. The first stage of the process is an initial screening wherein activities which cannot have, because they do not spatially overlap with a given habitat or have a clear pathway for interaction, any impact on the conservation features and are therefore excluded from further consideration. The next phase is the Natura Impact Statement (NIS) where interactions (or risk of) are identified. Further to this, an assessment on the significance of the

likely interactions between activities and conservation features is conducted. Mitigation measures (if necessary) will be introduced in situations where the risk of significant disturbance is identified. In situations where there is no obvious mitigation to reduce the risk of significant impact, it is advised that caution should be applied in licencing decisions. Overall the Appropriate Assessment is both the process and the assessment undertaken by the competent authority to effectively validate this Screening Report and/or NIS. It is important to note that the screening process is considered conservative in that other activities which may overlap with habitats but which may have very benign effects are retained for full assessment. In the case or risk assessments consequence and likelihood of the consequence occurring are scored categorically as separate components of risk. Risk scores are used to indicate the requirement for mitigation.

2.4 DATA SUPPORTS

Distribution of habitats and species population data are provided by NPWS[1]. Scientific reports on the potential effects of various activities on habitats and species have been compiled by the MI and provide the evidence base for the findings. The profile of aquaculture activities was provided by BIM. The data supporting the assessment of individual activities vary and provides for varying degrees of confidence in the findings.

2.5 FINDINGS

In Bannow Bay SAC there are eight existing oyster production licences with a further seventeen new applications. The likely interaction of aquaculture activity occurring at licenced sites, application sites and along access routes with conservation features (habitats and species) of the site was considered.

An initial screening exercise resulted in a number of habitat features and species being excluded from further consideration. None of the aquaculture activities (existing and/or proposed) overlaps or likely interacts with the following features or species, and therefore the following habitats and species were excluded from further consideration in the assessment:

- 1130 Estuaries
- 1210 Annual vegetation of drift lines
- 1220 Perennial vegetation of stony banks
- 1310 Salicornia and other annuals colonizing mud and sand
- 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
- 1410 Mediterranean salt meadows (*Juncetalia maritimi*)
- 1420 Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)
- 2110 Embryonic shifting dunes
- 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes')

[1] NPWS Geodatabase Ver: January 2016 - http://www.npws.ie/mapsanddata/habitatspeciesdata/

- 2130 *Fixed coastal dunes with herbaceous vegetation ('grey dunes')

A full assessment was carried out on the likely interactions between aquaculture operations and the feature Annex 1 habitat Mudflats and sandflats not covered by seawater at low tide (1140). The likely effects of existing and proposed aquaculture activities were considered in light of the sensitivity of the constituent communities of the Annex 1 habitat 1140 which overlap with current and proposed intertidal oyster namely; Fine sands with *Pygospio elegans* and *Corophium volutator* community complex and, Intertidal sand dominated by polychaetes community complex.

In summary, it is concluded (based primarily upon the spatial overlap and sensitivity analysis) current and proposed intertidal aquaculture activities individually and in-combination do not pose a risk of significant disturbance to the conservation of habitats in Bannow Bay SAC.

3 INTRODUCTION

This document assesses the potential ecological interactions of aquaculture and fisheries activities within the Bannow Bay SAC (Site code: 000697) on the Conservation Objectives (COs) of the site. The information upon which this assessment is based is a list of applications and extant licences for aquaculture activities administered by the Department of Agriculture Food and Marine (DAFM) and forwarded to the Marine Institute as of May 2015; as well as aquaculture and fishery profiling information provided on behalf of the operators by Bord Iascaigh Mara (BIM). The spatial extent of aquaculture licences is derived from a database managed by the DAFM[2] and shared with the Marine Institute.

4 CONSERVATION OBJECTIVES FOR BANNOW BAY SAC

The appropriate assessment of aquaculture and fisheries in relation to the Conservation Objectives for Bannow Bay SAC is based on Version 1.0 of the objectives (NPWS 2012a - Version 1 July 2012) and supporting documentation (NPWS 2012b - Version 1 February 2012; NPWS 2011 - Version 1 November 2011). The spatial data for conservation features was provided by NPWS[3].

4.1 THE SAC EXTENT

Bannow Bay SAC is a relatively large estuarine site, approximately 14km long on the south coast of County Wexford (Figure 4.1). It is a typical coastal estuary with large areas of mud and sand, and restricted access to the sea. Small rivers and streams to the north and south-west flow into the bay and their sub-estuaries form part of the site. The southern end of the bay supports a mosaic of sand dunes, saltmarshes, sea cliffs of clay and rock and extensive sandy beaches. The extent of the SAC is shown in Figure 4.1 below.

4.2 QUALIFYING INTERESTS (SAC)

The SAC is designated for the following habitats and species (NPWS 2012a), as listed in Annex I and Annex II of the Habitats Directive:

- 1130 Estuaries
- 1140 Mudflats and sandflats not covered by seawater at low tide
- 1210 Annual vegetation of drift lines
- 1220 Perennial vegetation of stony banks
- 1310 Salicornia and other annuals colonizing mud and sand
- 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)

[2] DAFM Aquaculture Database version Aquaculture: May, 2015
[3] NPWS Geodatabase Ver: January 2016 - http://www.npws.ie/mapsanddata/habitatspeciesdata/

- 1410 Mediterranean salt meadows (*Juncetalia maritimi*)
- 1420 Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)
- 2110 Embryonic shifting dunes
- 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes')
- 2130 *Fixed coastal dunes with herbaceous vegetation ('grey dunes')

The spatial extent of the Qualifying Interest Annex 1 marine habitats Estuaries (1130) and Mudflats and sandflats not covered by seawater at low tide (1140) is illustrated in Figure 4.2 and Figure 4.3 respectively (from NPWS (2011c)).

Constituent communities and community complexes recorded within the Annex 1 Qualifying Interests of Estuaries (1130) and Mudflats and sandflats not covered by seawater at low tide (1140) are listed in NPWS (2011c) and illustrated in Figure 4.4 and presented in Table 4.1 below.

Table 4.1 - The community types recorded in Bannow Bay SAC and the Annex I habitats in which they occur (NPWS 2011c).

Community Type	Annex I Habitats	
	Estuaries (1130)	Mudflats and sandflats not covered by seawater at low tide (1140)
Fine sands with *Pygospio elegans* and *Corophium volutator* community complex	✓	✓
Intertidal sand dominated by polychaetes community complex		✓
Zostera-dominated community		✓
Barnea candida community		✓

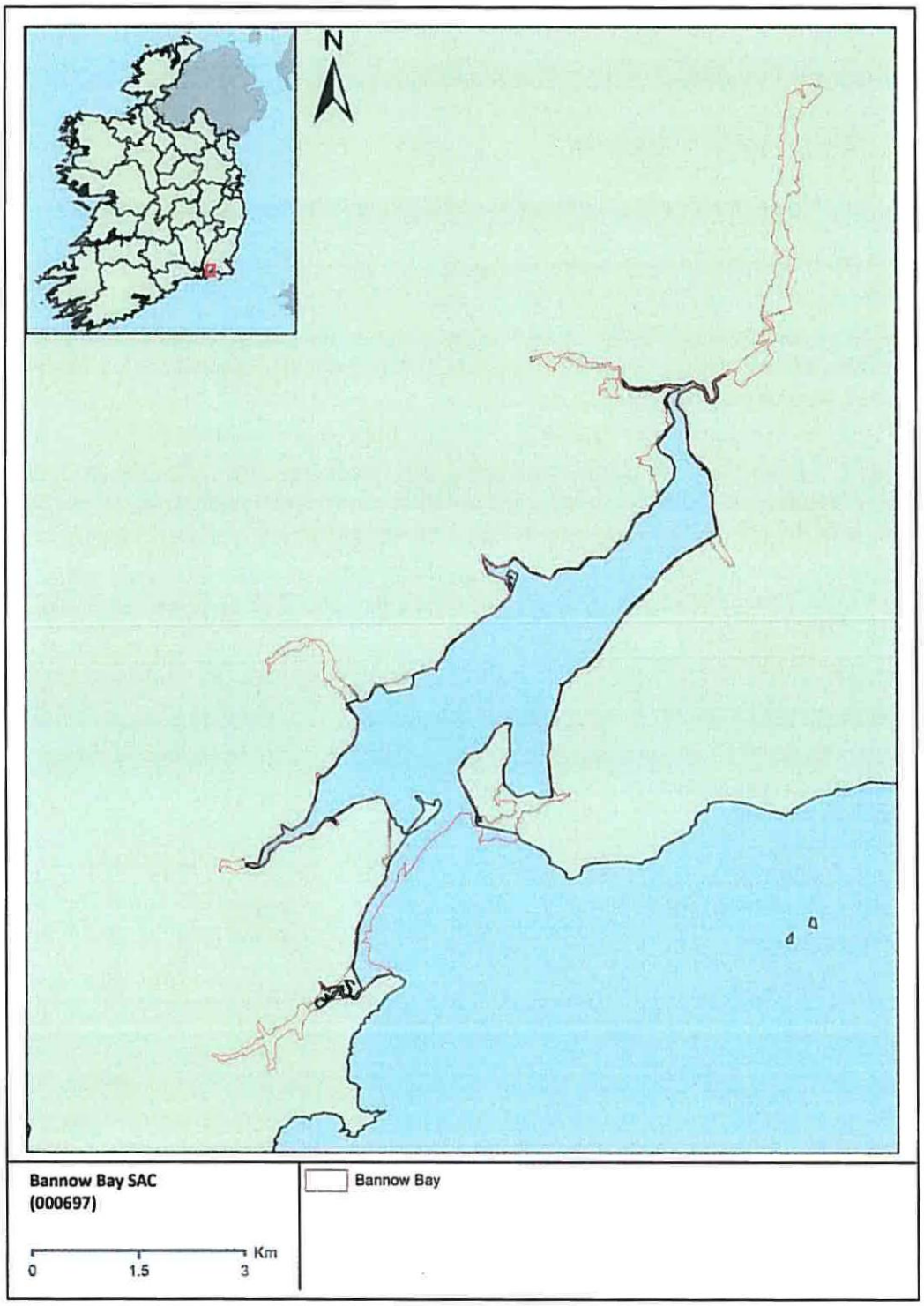

Figure 4-1 - The extent of the Bannow Bay SAC (NPWS 2011c).

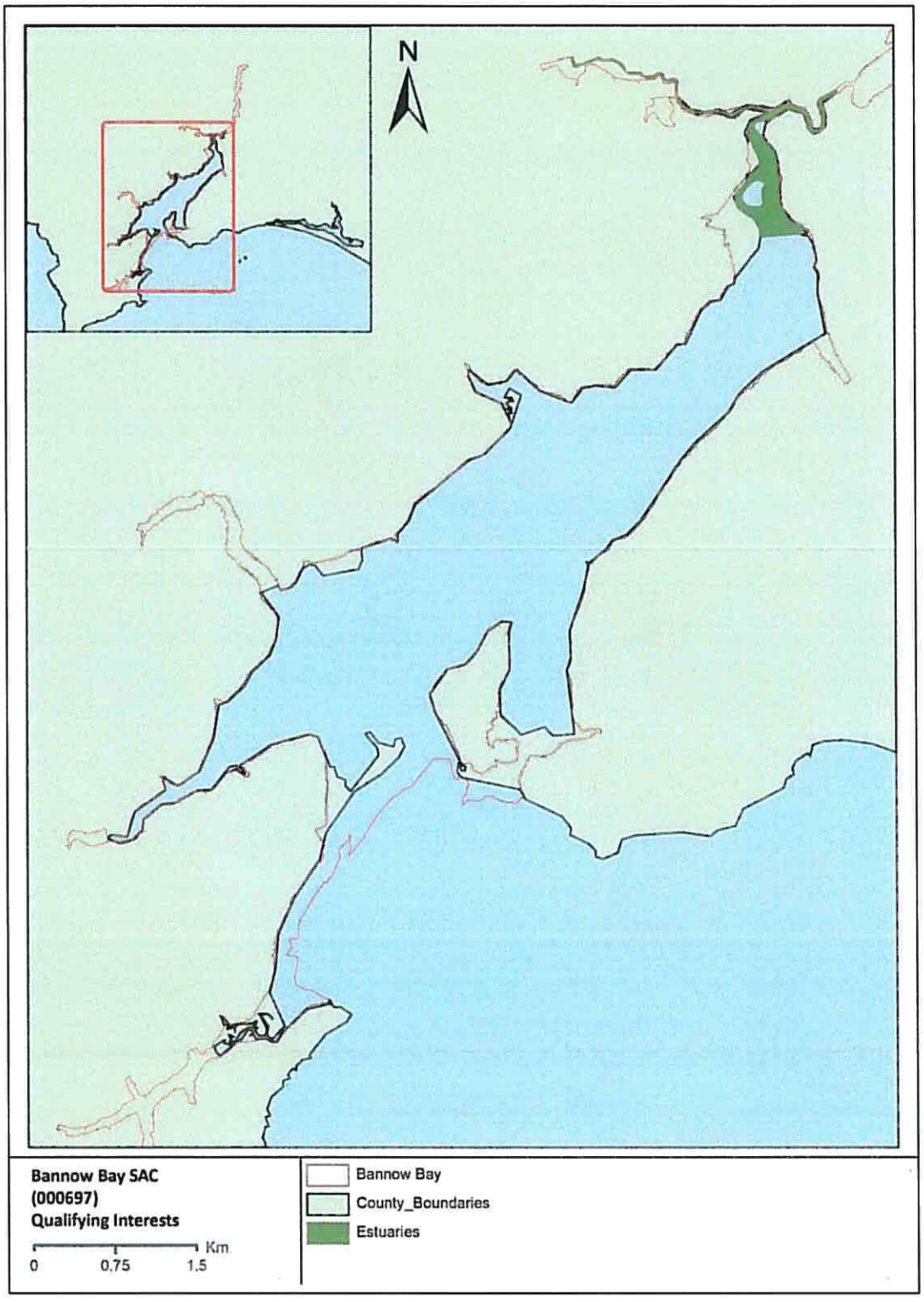

Figure 4-2 - The extent of the marine Annex I Qualifying Interest of Estuaries (1130) within the Bannow Bay SAC (NPWS 2011c).

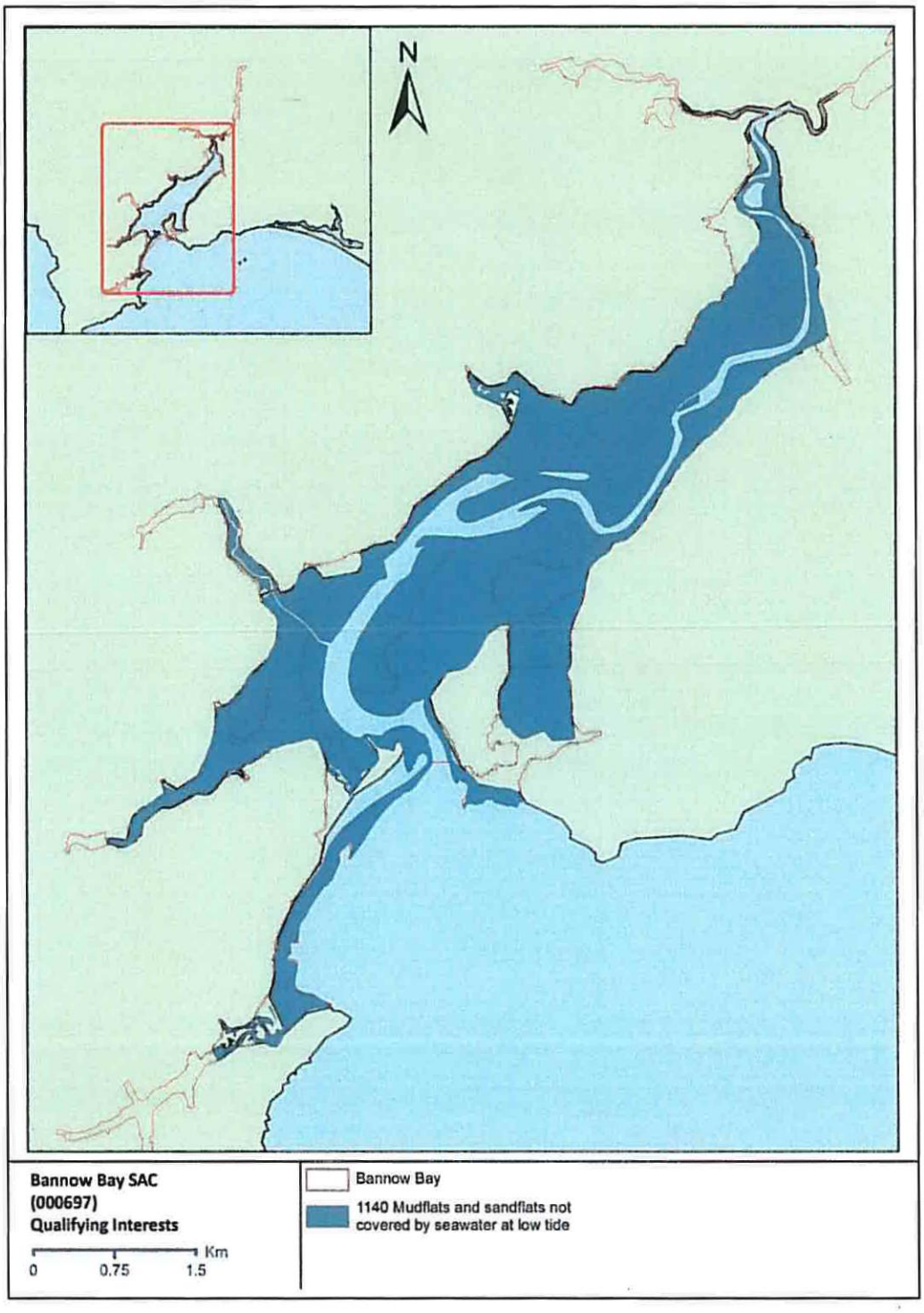

Figure 4-3 - The extent marine Annex I Qualifying Interest of Mudflats and sandflats not covered by seawater at low tide (1140) (NPWS 2011c).

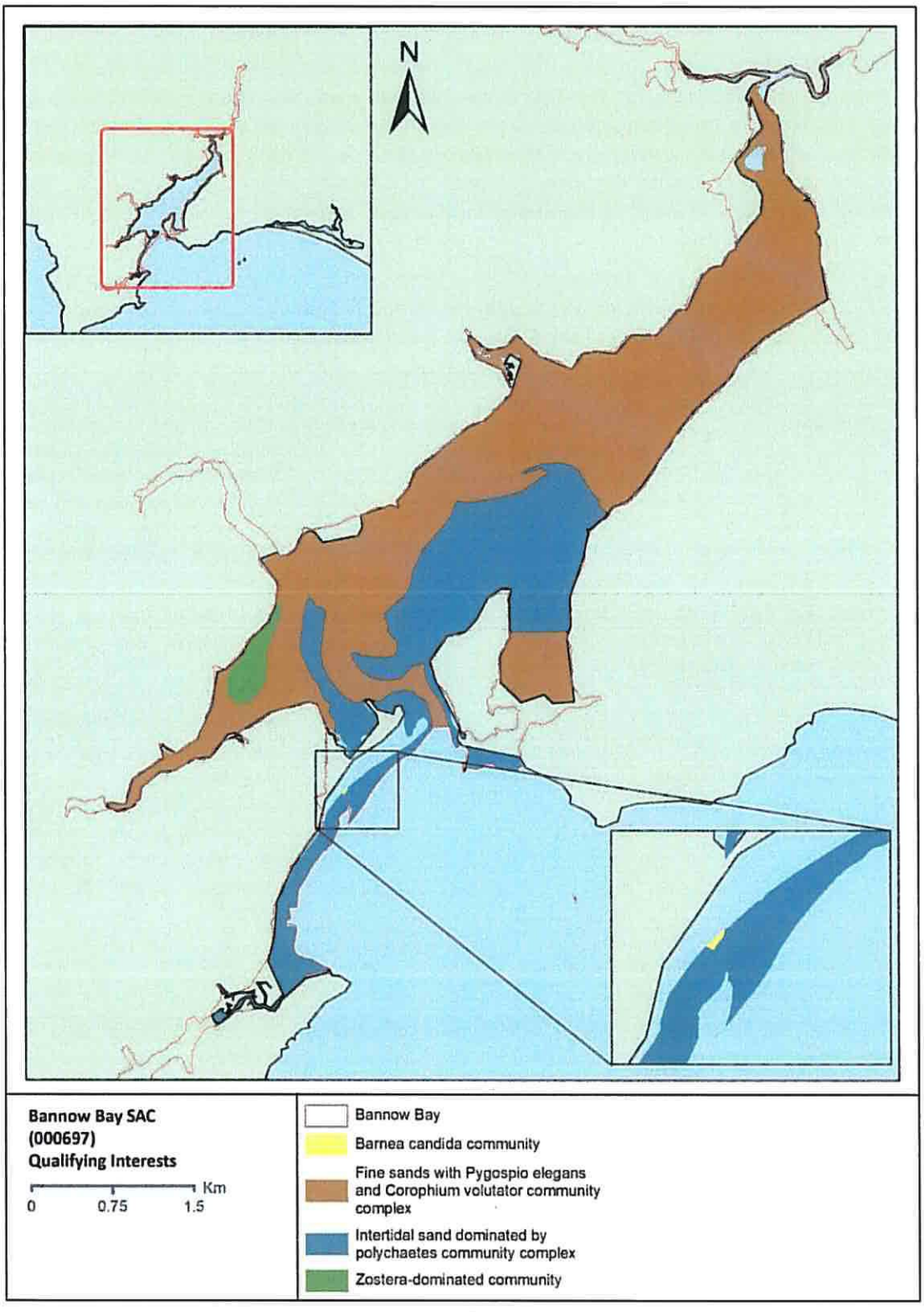

Figure 4-4 - Principal benthic communities recorded within the marine Annex I Qualifying Interest of Estuaries (1130) and Mudflats and sandflats not covered by seawater at low tide (1140) within the Bannow Bay SAC (NPWS 2011c).

4.3 CONSERVATION OBJECTIVES FOR BANNOW BAY SAC

The conservation objectives for the Qualifying Interests were identified in NPWS (2012a). The natural condition of the designated features should be preserved with respect to their area, distribution, extent and community distribution. Habitat availability should be maintained for designated species and human disturbance should not adversely affect such species. The features, objectives and targets of each of the Qualifying Interests within the SAC are listed in Table 4.2 below.

Table 4.2 - Conservation objectives and targets for marine habitats and species in Bannow Bay SAC (NPWS 2012a, 2012b, 2011). Annex I and II features listed in **bold**.

Feature (Community Type)	Objective	Target(s)
Estuaries (1130)	Maintain favourable conservation condition	34ha; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species
(Fine sands with *Pygospio elegans* and *Corophium volutator* community complex)	Maintain favourable conservation condition	The likely area of sediment communities was derived from intertidal and subtidal surveys undertaken in 2009. Maintain in a natural condition
Mudflats and sandflats not covered by seawater at low tide (1140)	Maintain favourable conservation condition	891.95ha;Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species
(Fine sands with *Pygospio elegans* and *Corophium volutator* community complex	Maintain favourable conservation condition	556.32ha; Maintain in a natural condition
(Intertidal sand dominated by polychaetes community complex)	Maintain favourable conservation condition	317.15ha; Maintain in a natural condition
(*Zostera*-dominated community)	Maintain favourable conservation condition	~18ha; Maintain natural extent and high quality of *Zostera* dominated communities
(*Barnea candida* community)	Maintain favourable conservation condition	Targets relate to maintaining population densities and extent of community.
Annual vegetation of drift lines (1210)	Maintain favourable conservation condition	Two sub-sites were mapped giving a total estimated area of 0.025ha (n.b. habitat is very difficult to measure in view of its dynamic nature and can appear and disappear within a site from year to year); Targets are identified that focus on a wide range of attributes with the

Feature (Community Type)	Objective	Target(s)
		ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
Perennial vegetation of stony banks (1220)	Maintain favourable conservation condition	Current area unknown. There is one area recorded at the Grange sub-site (0.05ha); Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
Salicornia and other annuals colonizing mud and sand (1310)	Restore favourable conservation condition	Habitat recorded at six of the seven sub-sites mapped and mapped, giving a total estimated area of 0.15ha (n.b. further unsurveyed areas maybe present within the site); Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) (1330)	Restore favourable conservation condition	Seven sub-sites mapped giving a total estimated area of 29.87ha (n.b. further unsurveyed areas maybe present within the site); Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
Mediterranean salt meadows (*Juncetalia maritimi*) (1410)	Restore favourable conservation condition	Five sub-sites mapped giving a total estimated area of 4.41ha (n.b. further unsurveyed areas maybe present within the site); Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) (1420)	Restore favourable conservation condition	Four sub-sites mapped giving a total estimated area of 0.36ha (n.b. further unsurveyed areas maybe present within the SAC; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of

Feature (Community Type)	Objective	Target(s)
		favourable species and managing levels of negative species.
Embryonic shifting dunes (2110)	Restore favourable conservation condition	Grange sub-site mapped giving a total estimated area of 1.37ha (n.b. habitat is very difficult to measure in view of its dynamic nature); Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes) (2120)	Restore favourable conservation condition	Habitat mapped at two sub-sites to give a total estimated area of 0.66ha (n.b. habitat is very difficult to measure in view of its dynamic nature); Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
Fixed coastal dunes with herbaceous vegetation (grey dunes) (2130)	Restore favourable conservation condition	Habitat mapped at two sub-sites to give a total estimated area of 4.05ha further unsurveyed areas maybe present within the site); Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.

4.4 SCREENING OF ADJACENT SAC OR FOR *EX-SITU* EFFECTS

In addition to the Bannow Bay SAC there are two other SAC sites proximate to the proposed activities (Figure 4.5). The characteristic features of these sites are identified in Table 4.3 where a preliminary screening is carried out on the likely interaction with aquaculture activities within Bannow Bay SAC based primarily upon the likelihood of spatial overlap. As it was deemed that there are no *ex-situ* effects and no effects on features in adjacent SACs all qualifying features of the adjacent SACs sites were screened out.

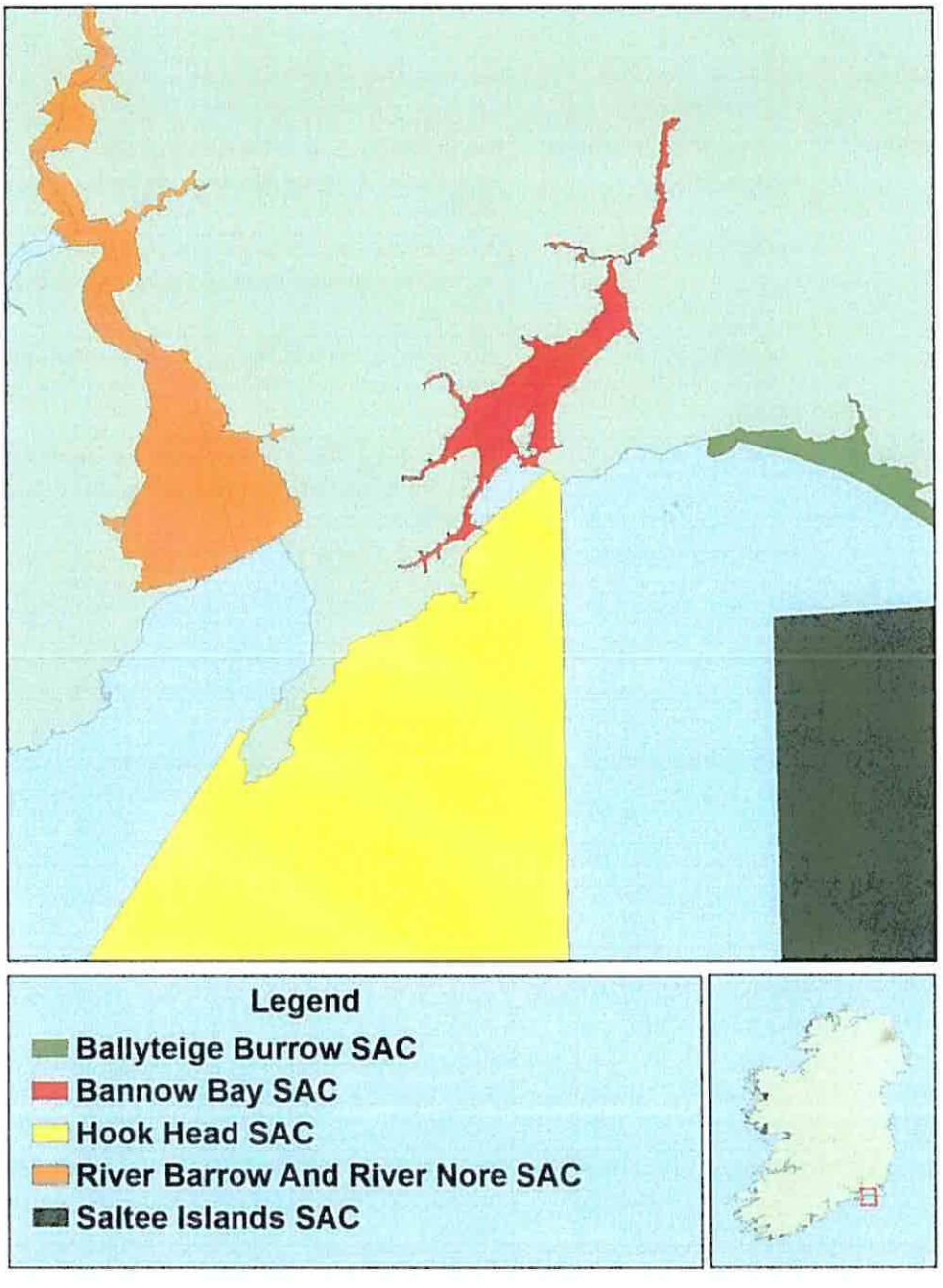

Figure 4-5 – SACs adjacent to the Bannow Bay SAC

Table 4.3 - SAC sites adjacent to the Bannow Bay SAC and qualifying features with initial screening assessment on likely interactions with aquaculture activities.

Natura site (Site code)	Qualifying features (habitat/species code)	Aquaculture initial screening
Hook Head SAC (000764)	**Large shallow inlets and bays (1160)**	**No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.**
	Reefs (1170)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Vegetated sea cliffs of the Atlantic and Baltic coasts (1230)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
Ballyteige Burrow SAC (000696)	Estuaries (1130)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Mudflats and sandflats not covered by seawater at low tide (1140)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Coastal lagoons (1150)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Annual vegetation of drift lines (1210)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Perennial vegetation of stony banks (1220)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Salicornia and other annuals colonising mud and sand (1310)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Spartina swards (*Spartinion maritimae*) (1320)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Atlantic salt meadows (Glauco-Puccinellietalia maritimae) (1330)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Mediterranean salt meadows (*Juncetalia maritimi*) (1410)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) (1420)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Embryonic shifting dunes (2110)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.

Natura site (Site code)	Qualifying features (habitat/species code)	Aquaculture initial screening
	(2120)	
	Fixed coastal dunes with herbaceous vegetation (grey dunes) (2130)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Atlantic decalcified fixed dunes (*Calluno-Ulicetea*) (2150)	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
Saltee Island SAC (000707)	Mudflats and sandflats not covered by seawater at low tide [1140]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Large shallow inlets and bays [1160]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Reefs [1170]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Vegetated sea cliffs of the Atlantic and Baltic coasts [1230]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Submerged or partially submerged sea caves [8330]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Halichoerus grypus (Grey Seal) [1364	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
River Barrow and River Nore SAC (002162)	Estuaries [1130]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Mudflats and sandflats not covered by seawater at low tide [1140]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Reefs [1170]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Salicornia and other annuals colonising mud and sand [1310]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Mediterranean salt meadows (Juncetalia maritimi) [1410]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation [3260]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	European dry heaths [4030]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further

Natura site (Site code)	Qualifying features (habitat/species code)	Aquaculture initial screening
		analysis.
	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels [6430]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Petrifying springs with tufa formation (Cratoneurion) [7220]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Old sessile oak woods with Ilex and Blechnum in the British Isles [91A0]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae) [91E0]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Vertigo moulinsiana (Desmoulin's Whorl Snail) [1016]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Margaritifera margaritifera (Freshwater Pearl Mussel) [1029]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Austropotamobius pallipes (White-clawed Crayfish) [1092]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Petromyzon marinus (Sea Lamprey) [1095]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Lampetra planeri (Brook Lamprey) [1096]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Lampetra fluviatilis (River Lamprey) [1099]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Alosa fallax fallax (Twaite Shad) [1103]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Salmo salar (Salmon) [1106]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Lutra lutra (Otter) [1355]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Trichomanes speciosum (Killarney Fern) [1421]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.
	Margaritifera durrovensis (Nore Pearl Mussel) [1990]	No spatial overlap or likely interactions with aquaculture activities in Bannow Bay SAC – excluded from further analysis.

5 DETAILS OF THE PROPOSED PLANS AND PROJECTS

5.1 DESCRIPTION OF AQUACULTURE ACTIVITIES

This assessment focuses on aquaculture activities which occur within the Qualifying Interest of Mudflats and sandflats not covered by seawater at low tide (1140) for which the Bannow Bay SAC is designated. Aquaculture activities within the SAC focus on the cultivation of the Pacific oyster *C. gigas*. Descriptions of spatial extents of existing and proposed aquaculture activities within the Qualifying Interest were calculated using coordinates of activity areas in a GIS. The spatial extent of the activities occurring at current and proposed cultivation sites overlapping the Qualifying Interest of 1140 is presented in Table 5.1 and presented graphically in Figure 5.1 (data provided by DAFM) while the spatial extent of access routes is presented in Table 5.2 and Figure 5.1.

5.1.1 Current Oyster Cultivation

Current oyster cultivation within Bannow Bay SAC is a form of intensive culture with oyster seed cultivated using the bag and trestle method within the intertidal zone, either to half-grown or fully-grown size. The bag and trestle method uses steel table-like structures which rise from the shore to just above knee height on the middle to lower intertidal zone, arrayed in double rows with wide gaps between the paired rows to allow for access. Trestles used are made from steel and typically between 3 in length, are approximately 1 metre in width and stand between 0.5 and 0.7 metre in height. In general, oyster farms are positioned between mean Low Water Spring and mean Low Water Neap, allowing on average between 2 and 5 hours exposure depending on location, tidal and weather conditions. The trestles hold typically hold six HDPE mesh bags approximately 1m by 0.5m by 10cm, using rubber and wire clips to close the mesh bags and to fasten them to the trestles. Oyster bags vary in mesh size (4mm, 6mm, 9mm and 14 mm) depending on oyster stock grade. For example 6mm seed is put into 4mm mesh bags at a ratio of 1000 to 1500 seed per bag. Both Diploid and Triploid oysters are grown in the Bay. The oyster seed is bought in from oyster nurseries in France or the UK and include;

- GrainOcean
- France Turbot
- Satmar
- France Nissian

Oysters are thinned out and graded as the oysters grow. As the oysters grow, they will be taken to the handling / sorting facility twice per year for grading and re-packing, and returned to the trestles. In the final stage they will be 'hardened' in the upper intertidal area, before removal, grading, bagging and delivery. Time to harvest, depending on intake size, ranges from 2.5 to 4 years, where they will have reached 60 or 80 to the kilo. At reaching market size oysters are in bags of about 120. Some farmers also take in half grown oysters and contract grow for local farmers in the area.

There are three main pacific oyster production areas within Bannow Bay; the North and South of the bay, with one producer farming in the West of the bay. Farms on the intertidal area are typically accessed during spring tides (at low tide) using vans or tractors. Preparatory work is always conducted in the service areas in the intervening periods, including grading and packing, preparation of bags and trestles and general maintenance work which includes shaking and turning of bags, and hand removal of fouling and seaweed to ensure maintenance of water flow through the bags when submerged.

5.1.1.1 Proposed Oyster Cultivation Activity

There are a total of seventeen new applications for production in the SAC all of which have indicated their source of seed will be from hatcheries currently used by existing farms within the Bay (Table 5.1). All new applicants are to use bag and trestles as the method of cultivating their oysters. There will be both diploid and triploid (if available) seed used on site.

5.1.1.2 Access Routes

There is a number of access routes in Bannow Bay (Figure 5.1) used by boats as well as tractors and trailers to access main production areas of the Bay. Access route spatial coverage is calculated by multiplying the linear measurement of the route by 10m, which give a conservative estimate of the are covered. Access routes overlap with less than 1% of the Qualifying Interest of 1140 Mudflats and sandflats not covered by seawater at low tide (Table 5.2).

Table 5.1 - Spatial extent of aquaculture activities overlapping with the Qualifying Interest (1140 Mudflats and sandflats not covered by seawater at low tide) in Bannow Bay SAC (Site Code 000697), presented according to license status. Spatial data based on licence database provided by DAFM. Habitat data provided in NPWS 2011c.

Culture Type	Status	Mudflats and sandflats not covered by seawater at low tide (1140); 891.95ha		
		Number of Licences	Area overlap (ha)	% Overlap
Oysters	Application	17	73.8	8.21
Oysters	Licensed	8	18.9	2.11
	Total	25	92.71	10.04

Table 5.2 - Spatial extent of aquaculture access routes overlapping with the Qualifying Interest (1140 Mudflats and sandflats not covered by seawater at low tide) in Bannow Bay SAC (Site Code 000697). Spatial data based on licence database provided by DAFM. Habitat data provided in NPWS 2011c.

Activity	Mudflats and sandflats not covered by seawater at low tide (1140); 891.95ha	
	Area overlap (ha)	% Overlap
Access Routes	4.74	0.53

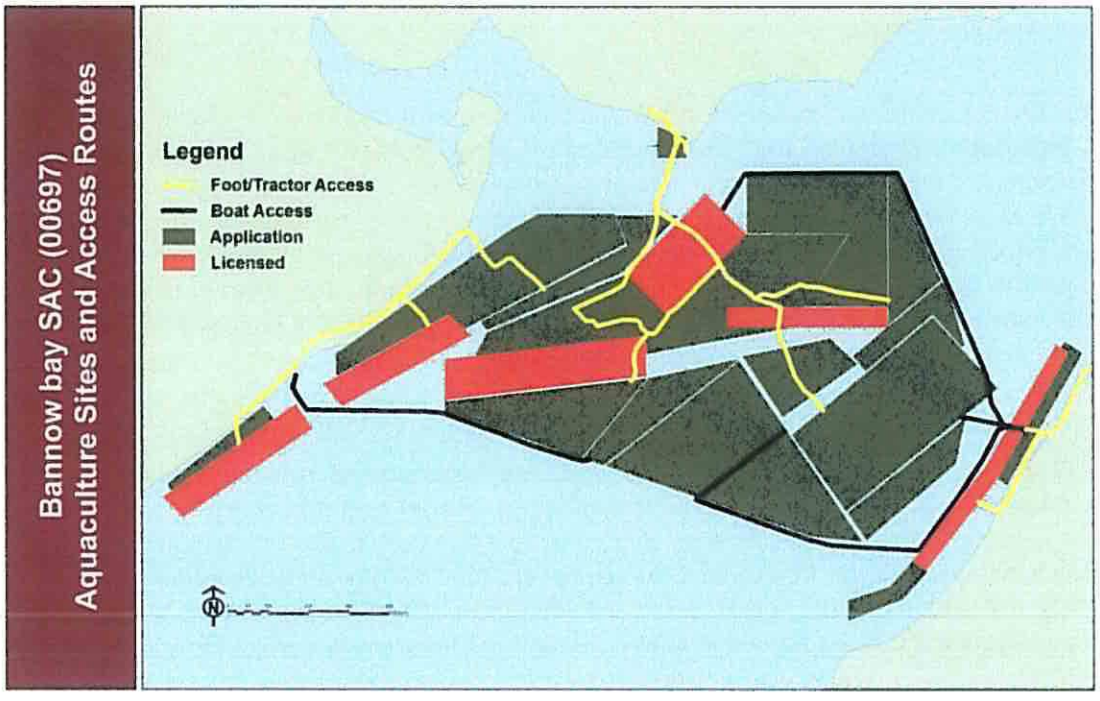

Figure 5-1 - Aquaculture sites (licenced and applications) and access routes of Bannow Bay SAC (NPWS 2011c).

6 NATURA IMPACT STATEMENT FOR THE PROPOSED ACTIVITIES

The potential ecological effects of activities on the conservation objectives for the site relate to the physical and biological effects of aquaculture cultivation structures and activities and human activities on designated species, intertidal habitats and invertebrate communities and biotopes within those broad habitat types. The overall effect on the conservation status will depend on the spatial and temporal extent of fishing and aquaculture activities during the lifetime of the proposed plans and projects and the nature of each of these activities in conjunction with the sensitivity of the receiving environment.

6.1 AQUACULTURE

Within the Qualifying Interest of the Bannow Bay SAC the species cultured is the Pacific oyster *C. gigas* in bags & trestles in the intertidal area.

Details of the potential biological and physical effects of these aquaculture activities on the habitat features, their sources and the mechanism by which the impact may occur are summarised in Table

6.1 below. The impact summaries identified in the table are derived from published primary literature and review documents that have specifically focused upon the environmental interactions of mariculture (e.g. Black 2001; McKindsey et al 2007; NRC 2010; O'Beirn et al 2012; Cranford et al 2012; ABPMer 2013a-h).

Filter feeding organisms, for the most part, feed at the lowest trophic level, usually relying primarily on ingestion of phytoplankton. The process is extractive in that it does not rely on the input of feedstuffs in order to produce growth. Suspension feeding bivalves such as oysters and mussels can modify their filtration to account for increasing loads of suspended matter in the water and can increase the production of faeces and pseudofaeces (non-ingested material) which result in the transfer of both organic and inorganic particles to the seafloor. This process is a component of benthic-pelagic coupling. The degree of deposition and accumulation of biologically derived material on the seafloor is a function of a number of factors discussed below.

One aspect to consider in relation to the culture of shellfish is the potential risk of alien species arriving into an area among consignments of seed or stock sourced from outside of the area under consideration. When the seed is sourced locally (e.g. mussel culture) the risk is likely zero. When seed is sourced at a small size from hatcheries in Ireland the risk is also small. When seed is sourced from hatcheries outside of Ireland (this represents the majority of cases particularly for oyster culture operations) the risk is also considered small, especially if the nursery phase has been short. When ½-grown stock (oysters and mussels) is introduced from another area (e.g. France, UK) the risk of introducing alien species (hitchhikers) is considered greater given that the stock will have been grown in the wild (open water) for a prolonged period (i.e. ½-grown stock). Furthermore, the culture of a non-native species (e.g. the Pacific Oyster – *C. gigas*) may also presents a risk of establishment of this species in the SAC. Recruitment of *C. gigas* has been documented in a number of bays in Ireland and appears to have become naturalised (i.e. establishment of a breeding population) in two locations (Kochmann et al 2012; 2013) and may compete with the native species for space and food.

Intertidal shellfish culture: Oysters are typically cultured in the intertidal zone using a combination of plastic mesh bags and trestles. Their specific location in the intertidal is dependent upon the level of exposure of the site, the stage of culture and the accessibility of the site. Any habitat impact from oyster trestle culture is typically localised to areas directly beneath the culture systems. The physical presence of the trestles and bags may reduce water flow and allowing suspended material (silt, clay as well as faeces and pseudo-faeces) to fall out of suspension to the seafloor. The build-up of material will typically occur directly beneath the trestle structures and can result in accumulation of fine, organically rich sediments. These sediments may result in the development of infaunal communities distinct from the surrounding areas. Similar to suspended culture above, whether material accumulates beneath oyster trestles is dictated by a number of factors, including:

- Hydrography – low current speeds (or small tidal range) may result in material being deposited directly beneath the trestles. If tidal height is high and large volumes of water moved through the culture area an acceleration of water flow can occur beneath the trestles and bags, resulting in a scouring effect or erosion and no accumulation of material.

- Turbidity of water – as with suspended mussel culture, oysters have very plastic response to increasing suspended matter in the water column with a consequent increase in faecal or pseudo-faecal production. Oysters can be cultured in estuarine areas (given their polyhaline tolerance) and as a consequence can be exposed to elevated levels of suspended matter. If

currents in the vicinity are generally low, elevated suspended matter can result in increased build-up of material beneath culture structures.

- Density of culture – the density of oysters in a bag and consequently the density of bags on a trestle will increase the likelihood of accumulation on the seafloor. In addition, if the trestles are located in close proximity a greater dampening effect can be realised with resultant accumulations. Close proximity may also result in impact on shellfish performance due to competitive interactions for food.

- Exposure of sites - the degree to which the aquaculture sites are exposed to prevailing weather conditions will also dictate the level of accumulated organic material in the area. As fronts move through culture areas increased wave action will resuspend and disperse material away from the trestles.

Shading may be an issue as a consequence of the structures associated with intertidal oyster culture. The racks and bags are held relatively close to the seabed and as a consequence may shade sensitive species (e.g. seagrasses) found underneath.

Physical disturbance caused by compaction of sediment from foot traffic and vehicular traffic. Activities associated with the culture of intertidal shellfish include the travel to and from the culture sites and within the culture sites using tractors and trailers as well as the activities of workers within the site boundaries.

Other considerations: Due to the nature of the (high density) of shellfish culture methods the risk of transmission of disease within cultured stock is high. However, given that *C. gigas* does not appear to occur in the wild the risk of disease transmission to 'wild' stock is considered low. The risk of disease transmission from cultured oysters to other species is unknown.

Oyster culture poses a risk in terms of the introduction of non-native species as the Pacific oyster (*C. gigas*) is a non-native species. Recruitment of *C.* gigas has been documented in a number of Bays in Ireland and appears to have become naturalised (i.e. establishment of a breeding population) in two locations (Kochmann et al 2012; 2013) and may compete with the native species for space and food. The culture of large volumes of Pacific oysters may increase the risk of successful reproduction in Bannow Bay SAC. The use of triploid (non-reproducing) stock is the main method employed to manage this risk. Furthermore, the introduction of non-native species as 'hitchhikers' on and among culture stock is also considered a risk, the extent of which is dependent upon the duration the stock has spent 'in the wild' outside of Bannow Bay SAC. Half-grown stock (15 - 30g oysters) which would have been grown for extended periods in places (in particular outside of Ireland) present a higher risk. Oysters grown in other bays in Ireland and 'finished' in Bannow Bay SAC, would not appear to present a risk of introduction of non-native species assuming best practice is applied (e.g. http://invasivespeciesireland.com/cops/aquaculture/).

Table 6.1 - Potential indicative environmental pressures of aquaculture activities within the Qualifying Interest (Mudflats and sandflats not covered by seawater at low tide (1140)) of the Bannow Bay SAC.

Activity	Pressure category	Pressure	Potential effects	Equipment / Gear	Duration (days)	Time of year	Factors constraining the activity
Intertidal Oyster Culture	Physical	Current alteration	Structures may alter the current regime and resulting increased deposition of fines or scouring.	Trestles and bags and service equipment	365	All year	At low tide only
		Surface disturbance	Ancillary activities at sites, e.g. servicing, transport increase the risk of sediment compaction resulting in sediment changes and associated community changes.				
		Shading	Prevention of light penetration to seabed potentially impacting light sensitive species				
	Biological	Non-native species introduction	Potential for non-native species (*C. gigas*) to reproduce and proliferate in SAC. Potential for alien species to be included with culture stock (hitch-hikers).				
		Disease risk	In event of epizootic the ability to manage disease in uncontained subtidal oyster populations is compromised.				
		Organic enrichment	Faecal and pseudofaecal deposition on seabed potentially altering community composition				
	Physical	Current alteration	Structures may alter the current regime and resulting increased deposition of fines or scouring.				
		Shading	Prevention of light penetration to seabed potentially impacting light sensitive species				
		Fouling	Increased secondary production on structures and culture species.				

Activity	Pressure category	Pressure	Potential effects	Equipment / Gear	Duration (days)	Time of year	Factors constraining the activity
			Increased nekton production				
		Seston filtration	Alteration of phytoplankton and zooplankton communities and potential impact on carrying capacity				
		Nutrient exchange	Changes in ammonium and Dissolved inorganic nitrogen resulting in increased primary production. Nitrogen (N_2) removal at harvest.				
		Alien species	Introduction of non-native species with culture organism transported into the site				

7 SCREENING OF AQUACULTURE ACTIVITIES

A screening assessment is an initial evaluation of the possible impacts that activities may have on the Qualifying Interests. The screening, is a filter, which may lead to exclusion of certain activities or Qualifying Interests from appropriate assessment proper, thereby simplifying the assessments, if this can be justified unambiguously using limited and clear cut criteria. Screening is a conservative filter that minimises the risk of false negatives.

In this assessment screening of the Qualifying Interests against the proposed activities is based primarily on spatial overlap i.e. if the Qualifying Interests overlap spatially with the proposed activities then significant impacts due to these activities on the conservation objectives for the Qualifying Interests is not discounted (not screened out) except where there is absolute and clear rationale for doing so. Where there is relevant spatial overlap full assessment is warranted. Likewise if there is no spatial overlap and no obvious interaction is likely to occur, then the possibility of significant impact is discounted and further assessment of possible effects is deemed not to be necessary. Table 5.1 provides spatial overlap extent between designated habitat Qualifying Interest features and aquaculture activities within the Qualifying Interests of the Bannow Bay SAC (i.e. Estuaries (1130) and Mudflats and sandflats not covered by seawater at low tide (1140)).

7.1 AQUACULTURE ACTIVITY SCREENING

Where the overlap between an aquaculture activity and a qualifying feature is zero and there is no likely interaction identified, it is screened out and not considered further. Therefore, on this basis, the following habitats are excluded from further consideration in this assessment:

- 1130 Estuaries
- 1210 Annual vegetation of drift lines
- 1220 Perennial vegetation of stony banks
- 1310 Salicornia and other annuals colonizing mud and sand
- 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
- 1410 Mediterranean salt meadows (*Juncetalia maritimi*)
- 1420 Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)
- 2110 Embryonic shifting dunes
- 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes')
- 2130 *Fixed coastal dunes with herbaceous vegetation ('grey dunes')

Table 5.1 highlights the spatial overlap between (existing and proposed) aquaculture activities and qualifying habitat feature of Mudflats and sandflats not covered by seawater at low tide (1140). When overlap between aquaculture activity and a community habitat type and/or a feature of interest was observed it was quantified in a GIS application and presented on the basis of coverage of specific activity (representing different pressure types), licence status (licenced or application) intersecting with designated conservation features and/or sub-features (community types). Table 7.1 below provides an overview of overlap of aquaculture activities and specific marine community types of Fine sands with *Pygospio elegans* and *Corophium volutator* community complex, and Intertidal sand dominated by polychaetes community complex (identified from Conservation Objectives (i.e. NPWS 2012a)) within the broad habitat feature 1140.

A full assessment (see Section 8) was carried out on the likely interactions of aquaculture activities at licensed and application aquaculture sites with the community types of Fine sands with *Pygospio elegans* and *Corophium volutator* community complex and Intertidal sand dominated by polychaetes community complex (see Table 7.1 and Table 7.2).

Table 7.1 - Habitat utilisation i.e. spatial overlap of aquaculture activity over constituent community types within the Qualifying Interest 1140 (i.e. Fine sands with *Pygospio elegans* and *Corophium volutator* community complex and, Intertidal sand dominated by polychaetes community complex) in Bannow Bay SAC. Spatial data based on licence database provided by DAFM. Habitat data provided in NPWS 2011c.

Culture Type	Status	Number of Licences	Mudflats and sandflats not covered by seawater at low tide (1140); 891.95ha			
			Fine sands with *Pygospio elegans* and *Corophium volutator* community complex; 556.32ha		Intertidal sand dominated by polychaetes community complex; 317.15ha	
			Area overlap (ha)	% Overlap	Area overlap (ha)	% Overlap
Oysters	Application	17	73.8	13.27	0.003	0.001
Oysters	Licensed	8	18.9	3.4	-	-
	Sub-total	25	92.71	16.67	0.003	0.001

Table 7.2 - Spatial overlap of intertidal oyster cultivation site access routes with constituent community types within the Qualifying Interest 1140 (i.e. Fine sands with *Pygospio elegans* and *Corophium volutator* community complex and, Intertidal sand dominated by polychaetes community complex) in Bannow Bay SAC. Habitat data provided in NPWS 2011c.

Activity	Mudflats and sandflats not covered by seawater at low tide (1140); 891.95ha			
	Fine sands with *Pygospio elegans* and *Corophium volutator* community complex; 556.32ha		Intertidal sand dominated by polychaetes community complex; 317.15ha	
	Area overlap (ha)	% Overlap	Area overlap (ha)	% Overlap
Access Routes	4.74	0.85	-	-

8 ASSESSMENT OF AQUACULTURE ACTIVITIES

8.1 DETERMINING SIGNIFICANCE

The significance of the possible effects of the proposed activities on habitats, as outlined in the Natura Impact Statement (Section 6) and subsequent screening exercise (Section 7), is determined here in the assessment. The significance of effects is determined on the basis of Conservation Objective guidance for constituent habitats (NPWS 2011, 2012a).

Within the Bannow Bay SAC the qualifying habitats considered subject to potential disturbance and therefore, carried further in this assessment are:

- 1140 Mudflats and sandflats not covered by seawater at low tide

Habitats and species that are key contributors to biodiversity and which are sensitive to disturbance should be afforded a high degree of protection i.e. thresholds for impact on these habitats is low and any significant anthropogenic disturbance should be avoided. In the Bannow Bay SAC relevant sensitive key habitats/species include

- *Zostera*–dominated community - Screened out of further assessment based on no spatial overlap of the feature with aquaculture activities

For broad habitats and community types (Figures 4.2, 4.3, 4.4) significance of impact is determined in relation to, first and foremost, spatial overlap (see Section 7; Tables 5.1, 5.2, 7.1 and 7.2). Subsequent disturbance and the persistence of disturbance are considered as follows:

1. The degree to which the activity will disturb the Qualifying Interest. By disturb is meant change in the characterising species, as listed in the Conservation Objective guidance (NPWS 2011c) for constituent communities. The likelihood of change depends on the sensitivity of the characterising species to the activities in question. Sensitivity results from a combination of intolerance to the activity and/or recoverability from the effects of the activity (see Section 8.2 below).

2. The persistence of the disturbance in relation to the intolerance of the community. If the activities are persistent (high frequency, high intensity) and the receiving community has a high intolerance to the activity (i.e. the characterising species of the communities are sensitive and consequently impacted) then such communities could be said to be persistently disturbed.

3. The area of communities or proportion of populations disturbed. In the case of community disturbance (continuous or ongoing) of more than 15% of the community area it is deemed to be significant. This threshold does not apply to the sensitive habitat *Zostera* where any spatial overlap of activities should generally be avoided.

Effects will be deemed to be significant when cumulatively they lead to long term change (persistent disturbance) in broad habitat/features (or constituent communities) resulting in an impact greater than 15% of the area.

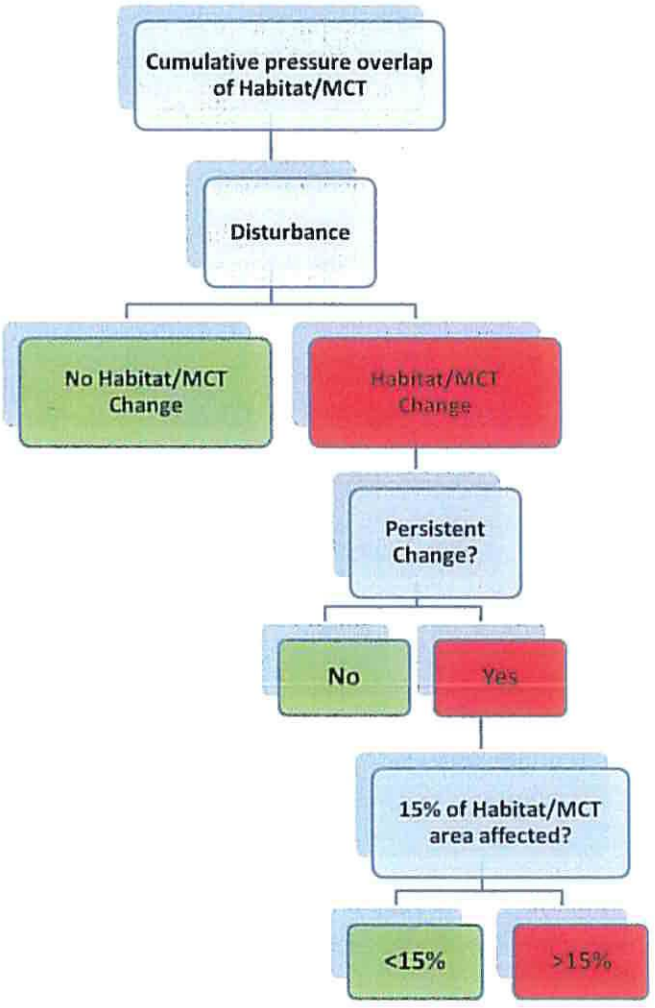

Figure 8.8-1 – Schematic outlining the determination of significant effects on habitats and marine community types (MCT) (following NPWS 2011c).

8.2 SENSITIVITY AND ASSESSMENT RATIONALE

This assessment used a number of sources of information in assessing the sensitivity of the characterising species of each community recorded within the benthic habitats of the Bannow Bay SAC. One source of information is a series of commissioned reviews by the Marine Institute which identify habitat and species sensitivity to a range of pressures likely to result from aquaculture and fishery activities (ABPMer 2013a-h). These reviews draw from the broader literature, including the MarLIN Sensitivity Assessment (Marlin.ac.uk) and the AMBI Sensitivity Scale (Borja et al 2000) and other primary literature. It must be noted that NPWS have acknowledged that given the wide range of community types that can be found in marine environments, they application of conservation targets to these would be difficult (NPWS 2011c). On this basis, they have proposed broad community complexes as management units. These complexes (for the most part) are very broad in their description and do not have clear surrogates which might have been considered in targeted studies and thus reported in the scientific literature. On this basis, the confidence assigned to likely interactions of the community types with anthropogenic activities are by necessity relatively low, with the exception of community types dominated by sensitive taxa, e.g. Mearl and *Zostera*. Other literature cited in the assessment does provide a greater degree of confidence in the conclusions. For example, the output of a recent study has provided greater confidence in terms of assessing

likely interactions between intertidal oyster culture and marine habitats (Forde et al 2015). Sensitivity of a species to a given pressure is the product of the intolerance (the susceptibility of the species to damage, or death, from an external factor) of the species to the particular pressure and the time taken for its subsequent recovery (recoverability is the ability to return to a state close to that which existed before the activity or event caused change). Life history and biological traits are important determinants of sensitivity of species to pressures from aquaculture.

In the case of species, communities and habitats of conservation interest, the separate components of sensitivity (intolerance, recoverability) are relevant in relation to the persistence of the pressure:

- For persistent pressures i.e. activities that occur frequently and throughout the year recovery capacity may be of little relevance except for species/habitats that may have extremely rapid (days/weeks) recovery capacity or whose populations can reproduce and recruit in balance with population damage caused by aquaculture. In all but these cases and if sensitivity is moderate or high then the species/habitats may be negatively affected and will exist in a modified state. Such interactions between aquaculture and species/habitat/community represent persistent disturbance. They become significantly disturbing if more than 15% of the community is thus exposed (NPWS 2014a).

- In the case of episodic pressures i.e. activities that are seasonal or discrete in time both the intolerance and recovery components of sensitivity are relevant. If sensitivity is high but recoverability is also high relative to the frequency of application of the pressure then the species/habitat/community will be in favourable conservation status for at least a proportion of time.

The sensitivities of the community types (or surrogates) found within the Bannow Bay SAC to pressures similar to those caused by aquaculture (e.g. smothering, organic enrichment and physical disturbance) are identified in Table 8.1. The sensitivities of species which are characteristic (as listed in the Conservation Objective supporting document) of benthic communities to pressures similar to those caused by aquaculture (e.g. smothering, organic enrichment and physical disturbance) are identified, where available, in Table 8.2. The following guidelines broadly underpin the analysis and conclusions of the species and habitat sensitivity assessment:

- Sensitivity of certain taxonomic groups such as emergent sessile epifauna to physical pressures is expected to be generally high or moderate because of their form and structure (Roberts et al 2010). Also high for those with large bodies and with fragile shells/structures, but low for those with smaller body size. Body size (Bergman and van Santbrink 2000) and fragility are regarded as indicative of a high intolerance to physical abrasion caused by fishing gears (i.e. dredges). However, even species with a high intolerance may not be sensitive to the disturbance if their recovery is rapid once the pressure has ceased.

- Sensitivity of certain taxonomic groups to increased sedimentation is expected to be low for species which live within the sediment, deposit and suspension feeders; and high for those sensitive to clogging of respiratory or feeding apparatus by silt or fine material.

- Recoverability of species depends on biological traits (Tillin et al 2006) such as reproductive capacity, recruitment rates and generation times. Species with high reproductive capacity, short generation times, high mobility or dispersal capacity may maintain their populations even when faced with persistent pressures; but such environments may become dominated by these (r-selected) species. Slow recovery is correlated with slow growth rates, low

fecundity, low and/or irregular recruitment, limited dispersal capacity and long generation times. Recoverability, as listed by MarLIN, assumes that the impacting factor has been removed or stopped and the habitat returned to a state capable of supporting the species or community in question. The recovery process is complex and therefore the recovery of one species does not signify that the associated biomass and functioning of the full ecosystem has recovered (Anand and Desrocher, 2004) cited in Hall et al 2008).

8.3 ASSESSMENT OF THE EFFECTS OF AQUACULTURE PRODUCTION ON THE CONSERVATION OBJECTIVES FOR HABITAT FEATURES IN THE BANNOW BAY SAC.

Aquaculture pressures on a given habitat are related to vulnerability (spatial overlap or exposure of the habitat to the equipment/culture organism combined with the sensitivity of the habitat) to the pressures induced by culture activities. To this end, the location and orientation of structures associated with the culture organism, the density of culture organisms, the duration of the culture activity and the type of activity are all important considerations when considering risk of disturbance to habitats and species.

NPWS (2011c) provide lists of species characteristic of benthic communities that are defined in the Conservation Objectives. The species defined are typical of fine sedimentary habitats as well as where relevant, intertidal habitats (tolerant of desiccation and physical stress). For the most part, these intertidal communities are typically impoverished with low numbers of species and overall abundances.

The constituent communities in the broad Annex 1 feature 1140 Mudflats and sandflats not covered by seawater at low tide) are:

- *Zostera*-dominated community - *(No overlap with aquaculture)*
- *Barnea candida* community - *(No overlap with aquaculture)*
- Intertidal sand dominated by polychaetes community complex
- Fine sand with *Pygospio elegans* and *Corophium volutator* community complex

For Mudflats and sandflats not covered by seawater at low tide (1140) there are a number of attributes (with associated targets) relating to the following broad habitat features as well as constituent community types;

1. **Habitat Area** - it is unlikely that the activities proposed will reduce the overall extent of permanent habitat within the feature Mudflats and sandflats not covered by seawater at low tide. The habitat area is likely to remain stable.

2. **Community Distribution - (conserve a range of community types in a natural condition)** - this attribute considered interactions with three of the community types listed above and exclude the sensitive community *Zostera*-dominated community. Of the three communities, one had no overlap with aquaculture activities (i.e. *Barnea candida* community). Therefore, the following community type, found within the Qualifying Interest 1140 of the SAC have overlap with aquaculture activities:

- Intertidal sand dominated by polychaetes community complex

- Fine sand with *Pygospio elegans* and *Corophium volutator* community complex

The community types listed above are predominantly sandy-muddy habitat types and given they are intertidal, can be exposed to a range of physical and hydrodynamic pressures. Table 8.1 lists the habitats (or surrogates) and Table 8.2 lists the constituent taxa and both provide a commentary of sensitivity to a range of pressures. The risk scores are derived from a range of sources identified above. The pressures are listed as those likely to result from intertidal oyster culture (bags and trestle) within the SAC.

Table 8.4 below identifies the likely interactions between the existing and proposed activities and the broad habitat feature (1140) and their constituent community types, with a broad conclusion and justification on whether the activity is considered disturbing to the feature in question. It must be noted that the sequence of distinguishing disturbance is as highlighted above, whereby activities with spatial overlap on habitat features are assessed further for their ability to cause persistence disturbance on the habitat. If persistent disturbance is likely then the spatial extent of the overlap is considered further. If the proportion of the overlap exceeds a threshold of 15% disturbance of the habitat then any further licencing should be informed by interdepartmental review and consultation (NPWS 2011c).

While the combined spatial overlap of current and proposed oyster cultivation sites and the constituent community types of Fine sands with *Pygospio elegans* and *Corophium volutator* community complex was 16.67% (see Table 7.1), published literature (Forde et al 2015; Carroll et al, 2016) suggests that activities occurring at trestle culture sites are considered to be non-disturbing to intertidal soft sediment communities. Access routes used in intertidal areas, presumably by virtue of persistent compaction of the sedimentary habitats, are considered disturbing (De-Grave et al 1998; Forde et al., 2015). The spatial overlap of access routes is 0.85% for Fine sand with *Pygospio elegans* and *Corophium volutator* community complex (see Table 7.2). Given this value is less than the 15% threshold, significant adverse impacts of activities on these community types **can be discounted**. However it should be noted that some sites appear to have considerable amounts of vehicular traffic contrary to the access routes outlined in the aquaculture profile. This is particularly relevant in the sites on the eastern portion of the bay which appear to be used for transit to other sites or as storage of unused trestles (Figure 8-2). This activity are considered disturbing and contrary to the information provided on site use in the profiling. Notwithstanding this, significant adverse impacts of activities on the Qualifying Feature of 1140 (Mudflats and sandflats not covered by seawater at low tide) and its constituent communities **can be discounted**.

Figure 8-2. Licenced sites subject to what appears as transport disturbance on the eastern shore of Bannow Bay (Image courtesy of Marine Institute).

3. ***Zostera*-dominated community Extent and Structure** – *Zostera*-dominated communities are considered highly diverse and sensitive habitat types which host a wide range of taxa. Given the highly sensitive natures of the community types and constituent taxa it is highly likely that aquaculture activities of any type which overlap the community type and the pressures may result in long-term or permanent change to the extent of these community types and impact upon their structure and function. In Bannow Bay SAC, however, aquaculture activity does not overlap with *Zostera* communities. Consequently, adverse impacts of aquaculture on the *Zostera* community complex **can be discounted**.

Introduction of non-native species: As already outlined oyster culture may present a risk in terms of the introduction of non-native species as the Pacific oyster (*Crassostrea gigas*) itself is a non-native species. Recruitment of *C. gigas* has been documented in a number of Bays in Ireland and appears to have become naturalised (i.e. establishment of a breeding population) in two locations (Kochmann et al 2012; 2013) and may compete with the native species for space and food. In addition to having large number of oysters in culture, Kochmann et al (2013) identified short residence times and large intertidal areas as factors likely contributing to the successful recruitment of oysters in Irish bays. Oyster production in the Bannow Bay SAC does not fulfil these criteria, as the residence time is between <1day to 9.8 days. Therefore the risk of successful establishment of the pacific oyster in Bannow Bay SAC is considered low.

8.3.1 Conclusion Summary

In summary, based upon the spatial overlap and sensitivity analysis, it is concluded that aquaculture activities at trestle sites and ate access route individually and in-combination do not pose a risk of significant disturbance to the conservation of the habitat feature of Mudflats and sandflats not covered by seawater at low tide (1140) or the constituent community types (Table 8.4).

Table 8.1 - **Matrix showing the characterising habitats sensitivity scores x pressure categories for habitats (or surrogates) in Bannow Bay SAC (ABPMer 2013a-h)** (Table 8.3 provides the code for the various categorisation of sensitivity and confidence.)

Community Type (EUNIS code)	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Trampling – access by foot	Trampling – access by vehicle	Extraction	Siltation (addition of fine sediments, pseudofaeces, fish food)	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments-sedimentation	Increased removal of primary production-phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
Muddy sand to coarse sediment with *Pygospio elegans* community complex (A2.23 – Polychaete/amphipod-dominated fine sand shore)	NS *	L *	L *	NS *	L-NS *	L-M *	L-M *	L-M *	L-M *	M *	L-M *	NS *	NS *	NS *	NS *	NS *	L-NS *	L-NS *	NS ***	NS *	NS *	NS *	NS *	L *	NS *
Sand with *Angulus tenuis* and *Scoloplos (Scoloplos) armiger* community complex (A2.24 – Polychaete/bivalve dominated fine sand shores)	NS ***	L *	L ***	NS *	L *	L-M *	L-M *	L-M *	L-M *	NS *	L-M *	NS *	NS *	NS *	NS *	NS *	L *	L *	H ***	NS *	NS *	NS *	NS *	L *	NS *

Table 8.2 - **Matrix showing the characterising species sensitivity scores x pressure categories for taxa (or surrogates) in Bannow Bay SAC (ABPMer 2013a-h)** (Table 8.3 provides the code for the various categorisation of sensitivity and confidence.)

Species	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Trampling – access by foot	Trampling – access by vehicle	Extraction	Siltation (addition of fine sediments, pseudofaeces, fish food)	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments-sedimentation	Increased removal of primary production-phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
Angulus tenuis	NS *	L *	L ***	NS *	L *	M *	NS *	H *	M-H *	NS *	L-M *	L *	NS *	NS *	Nev	L-NS *	NEv	NEv	M *	NS *	NS *	NS *	NEv	NEv	NS *
Arenicola marina	NS *	NS ***	L-M ***	NS ***	NS ***	L-M *	NS *	L-M *	L-M ***	L-M ***		NS *	NS *	NS *	NS *	NS *	NS ***	NS ***	M *	L-M *	NS *	NS ***	L **		NS *
Capitella sp.	L *	L **	L **	L ***	L *	L *	L *	NS *	NS *	NS ***	NS *	NS *	NS *	NS ***	NS ***	NS *	L ***	L ***	NS *	NS *	NS *	NS ***	L ***	NS ***	NS *
Cerastoderma edule	L *	L-M *	L-M ***	L-M ***	L-M *	L-H *	L ***	L-M *	L-H *	NS *	L *	NS *	NS *	NS *	NS **	L-NS *	L-M *	L-M *	M *	M *	NS *	NS *	NEv	L-M *	NS *
Corophium volutator	L ***	L** *	L ***	L *	L *	L *	L ***	L ***	M *	NS *	NS *	NS *	NS *	NS ***	NS ***	NS *	L ***	L ***	Nev	NS *	NS *	NA	NEv	L ***	NS *
Hediste diversicolor	NS *	L-M **	L-H **	NS *	L *	L-H *	NS ***	L-M *	M-H *	NS *	NS *	NS *	NS *	NS **	NS **	NS *	NS **	NS **	L-M *	L-M *	NS *	NS *	M-H **	M-H **	NS *
Lanice conchilega	NS *	NS-L ***	NS-L ***	NS *	NS-L *	M-H *	NS *	M-H *	NS *	NS ***	NS *	NS *	NS *	NS *	NS *	NS *	M *	M *	M-H *	NS *	NS *	NS *	NEv	L ***	NS *
Nemtoda	NS ***	NS ***	NS ***	NS ***	NS *	L *	NS *	NS ***	NS ***	NS ***	NS *	NS *	NS *	NS *	NS ***	NS *	L ***	L ***	NS ***	NS *	NS *	NS ***	Nev	L ***	NS *
Pygospio elegans	L *	L **	M ***	L *	L *	L-M *	L ***	L-M ***	L-M *	NS **	L-M *	NS *	NS *	NS *	NS ***	NS *	L **	L **	M *	NS *	NS *	NS *	NEv	NEv	NS *
Scoloplos (Scoloplos) armiger	NS *	L *	L-M *	NS *	L *	H *	NS *	NS *	NS *	NS *	NS *	NS *	NS *	NS ***	NS ***	NS *	M ***	M ***	M *	M **	NS *	NS *	NEv	NEv	NS *

Species	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Trampling – access by foot	Trampling – access by vehicle	Extraction	Siltation (addition of fine sediments, pseudofaeces, fish food)	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments-sedimentation	Increased removal of primary production-phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
Scolelepis (Scoloplos) squamata	NS *	NS ***	NS *	NS *	NS *	L-M *	L-M ***	L-M ***	NS *	NS *	NS *			NS *	NS ***	NS *	L *	L *		NS *	NS *	Nev	Nev		NS *
Scrobicularia plana	NS *	NS **	M-H *	NS **	L **	M-H *	NS-L *	M-H *	M-H *	NS *	NS *	L *	NS *	M *	M *	NS *	NS *	NS *	M *	NS *	NS *	NS *	NA	L *	NS *
Spio sp.	L *	L ***	L ***	L *	L *	L-M *	NS *	M *	L-M *	L-M *	NS *	NS *	NS *	NS *	NS ***	NS *	NEv	NEv	VH *	NS *	NS *	NS *	NEv	NS ***	NS *
Tubificoides sp.	NS *	NS *	L **	L *	L *	M *	NS *	L *	NS *	NS *	NS ***	NS *	NS *	NS ***	NS ***	NS *	NS ***	NS ***	NS *	NS *	NS *	NS **	Nev	Nev	NS **

Table 8.3 - Codes of sensitivity and confidence applying to species and pressure interactions presented in Tables 8.1 and 8.2.

Pressure interaction codes for Table 8.1 and 8.2	
NA	Not Assessed
Nev	No Evidence
NE	Not Exposed
NS	Not Sensitive
L	Low
M	Medium
H	High
VH	Very High
*	Low confidence
**	Medium confidence
***	High Confidence

Table 8.4 - Interactions between the relevant aquaculture activities and t and constituent communities of the habitat features of (1140) Mudflats and sandflats not covered by seawater at low tide with a broad conclusion on the interactions..

		Mudflats and sandflats not covered by seawater at low tide (1140); 891.95ha	
Culture Type	**Status**	**Fine sands with *Pygospio elegans* and *Corophium volutator* community complex; 556.32ha**	**Intertidal sand dominated by polychaetes community complex; 317.15ha**
Oysters	Application	**Disturbing: No** **Justification:** The activity overlaps 73.8ha or 13.27% of this community type. Published literature (Forde et al 2015) suggests that activities occurring at trestle culture sites are not disturbing.	**Disturbing: No** **Justification:** The activity overlaps 0.003ha or 0.003% of this community type. Published literature (Forde et al 2015) suggests that activities occurring at trestle culture sites are not disturbing.
Oysters	Licensed	**Disturbing: No** **Justification:** The activity overlaps 18.9ha or 3.4% of this community type. Published literature (Forde et al 2015) suggests that activities occurring at trestle culture sites are not disturbing.	-
Cumulative Impact Licensed and Proposed Aquaculture		**Disturbing: No** **Justification:** Published literature (Forde et al 2015) suggests that activities occurring at trestle culture sites are not disturbing.	**Disturbing: No** **Justification:** Published literature (Forde et al 2015) suggests that activities occurring at trestle culture sites are not disturbing

Table 8.5 - Interactions between access routes used for oyster aquaculture activities and constituent communities of the habitat features of (1140) Mudflats and sandflats not covered by seawater at low tide with a broad conclusion on the interactions.

Activity	**Mudflats and sandflats not covered by seawater at low tide (1140); 891.95ha**	
	Fine sands with *Pygospio elegans* and *Corophium volutator* community complex; 556.32ha	**Intertidal sand dominated by polychaetes community complex; 317.15ha**
Oyster Site Access Routes	**Disturbing: No** **Justification:** The spatial overlap with the community type is low at 0.85%. This value is below the spatial overlap threshold (15%) for significant adverse impacts of on this community type. However, some unquantified transport (disturbance on licenced sites) has been observed.	-

9 IN-COMBINATION EFFECTS OF AQUACULTURE, FISHERIES AND OTHER ACTIVITIES

9.1 FISHERIES

There are no known applications for a fishery, a Classified Production Area, or proposed fishery plans for the Bannow Bay SAC. On this basis, there are not likely to be any in-combination impacts between fishery and aquaculture activities.

9.2 POLLUTION PRESSURES

There are a number of activities which are terrestrial in origin that might result in impacts on the conservation features of the Bannow Bay SAC. Primary among these are point source discharges from domestic sewage outfalls distributed along the harbour. The pressure derived from these point sources may impact upon levels of dissolved nutrients, suspended solids and some elemental components e.g. aluminium in the case of water treatment facilities.

9.2.1 Conclusion Summary

Pressures resulting from aquaculture activities are primarily localised compaction of sediment along access routes. It was, therefore, concluded that given the pressure resulting from point discharge location such as the urban waste-water treatment and/or combined sewer outfalls would likely impact on physico-chemical parameters in the water column, any in-combination effects with aquaculture activities are considered to be **minimal or negligible**. It should be noted however the results of Shellfish Water monitoring[4] indicate water quality issues within/ in the vicinity of this shellfish area.

[4] Revised / Updated Bannow Bay Pollution Reduction Programme http://www.environ.ie/en/Publications/Environment/Water/PublicConsultations-ShellfishWatersDirective/FileDownLoad,33471,en.pdf

10 SAC AQUACULTURE APPROPRIATE ASSESSMENT CONCLUDING STATEMENT AND RECOMMENDATIONS

10.1 AQUACULTURE

In the Bannow Bay SAC oyster culture (using bags and trestles) is the only type of aquaculture activity currently occurring. Based upon this and the information provided in the aquaculture profiling carried out (Section 5), the likely interaction between this culture methodology and conservation features (habitats and species) of the site were considered.

10.1.1 Habitats

An initial screening exercise resulted in the features being excluded from further consideration by virtue of the fact that no spatial overlap of the culture activities was expected to occur; 1130 Estuaries, 1210 Annual vegetation of drift lines, 1220 Perennial vegetation of stony banks, 1310 Salicornia and other annuals colonizing mud and sand, 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*), 1410 Mediterranean salt meadows (*Juncetalia maritimi*), 1420 Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*), 2110 Embryonic shifting dunes, 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes') and 2130 Fixed coastal dunes with herbaceous vegetation ('grey dunes').

A full assessment was carried out on the likely interactions between existing and proposed culture operations and the feature of the Annex 1 habitat 1140 (Mudflats and sandflats not covered by seawater at low tide). The likely effects of the aquaculture activities (species, structures, access routes) were considered in light of the sensitivity of two (of four) constituent community types and species of the Annex 1 habitat 1140, i.e., Fine sands with *Pygospio elegans* and *Corophium volutator* community complex and, Intertidal sand dominated by polychaetes community complex.

Based upon the scale of spatial overlap of current and proposed aquaculture activities and the relatively high tolerance levels of the habitats and associated species, the general conclusion is that current activities are non-disturbing to the habitat Qualifying Interests and their constituent communities.

It is recommended that there be strict adherence to the access routes identified and that density of culture structures within the sites be maintained at current levels.

The movement of stock in and out of the Bannow Bay SAC should adhere to relevant fish health legislation and follow best practice guidelines (e.g. http://invasivespeciesireland.com/cops/aquaculture/).

11 REFERENCES

ABPMer. 2013a. Tools for appropriate assessment of fisheries and aquaculture activities in Marine and Coastal Natura 2000 sites. Report VIII: Vegetation dominated communities (Saltmarsh and Seagrass). Report No. R. 2053 for Marine Institute, Ireland.

ABPMer. 2013b. Tools for appropriate assessment of fisheries and aquaculture activities in Marine and Coastal Natura 2000 sites. Report VI: Biogenic reefs (*Sabellaria*, Native oyster, Maërl). Report No. R. 2068 for Marine Institute, Ireland.

ABPMer. 2013c. Tools for appropriate assessment of fisheries and aquaculture activities in Marine and Coastal Natura 2000 sites. Report I: Intertidal and Subtidal Muds. Report No. R. 2069 for Marine Institute, Ireland.

ABPMer. 2013d. Tools for appropriate assessment of fisheries and aquaculture activities in Marine and Coastal Natura 2000 sites. Report II: Intertidal and Subtidal Sands. Report No. R. 2070 for Marine Institute, Ireland.

ABPMer. 2013e. Tools for appropriate assessment of fisheries and aquaculture activities in Marine and Coastal Natura 2000 sites. Report III: Intertidal and Subtidal muddy sands and sandy muds. Report No. R. 2071 for Marine Institute, Ireland.

ABPMer. 2013f. Tools for appropriate assessment of fisheries and aquaculture activities in Marine and Coastal Natura 2000 sites. Report IV: Intertidal and Subtidal mixed sediments. Report No. R. 2072 for Marine Institute, Ireland.

ABPMer. 2013g. Tools for appropriate assessment of fisheries and aquaculture activities in Marine and Coastal Natura 2000 sites. Report IV: Intertidal and Subtidal coarse sediments. Report No. R. 2073 for Marine Institute, Ireland.

ABPMer. 2013h. Tools for appropriate assessment of fisheries and aquaculture activities in Marine and Coastal Natura 2000 sites. Report VII: Intertidal and Subtidal reefs. Report No. R. 2074 for Marine Institute, Ireland.

Bergman, M.J.N. and van Santbrink, J.W. 2000. Mortality in megafaunal benthic populations caused by trawl fisheries on the Dutch continental shelf in the North Sea 1994. ICES Journal of Marine Science 57(5), 1321-1331.

Black, K.D. (2001). Environmental impacts of aquaculture. Sheffield Biological Sciences, 6. Sheffield Academic Press: Sheffield. 214 pp

Borja, A., Franco, J. & Pérez, V. 2000. A marine biotic index of establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. Marine Pollution Bulletin. 40: 1100 – 1114.

Cranford, Peter J., Pauline Kamermans, Gesche Krause, Alain Bodoy, Joseph Mazurié, Bela Buck, Per Dolmer, David Fraser, Kris Van Nieuwenhove, Francis X. O'Beirn, Adoración Sanchez-Mata,

Gudrun G. Thorarinsdóttir, and Øivind Strand. 2012. An Ecosystem-Based Framework for the Integrated Evaluation and Management of Bivalve Aquaculture Impacts. Aquaculture Environment Interactions. 2:193-213

Forde, J., F. O'Beirn, J. O'Carroll, A. Patterson, R. Kennedy. 2015. Impact of intertidal oyster trestle cultivation on the Ecological Status of benthic habitats. Marine Pollution Bulletin 95, 223–233. doi:10.1016/j.marpolbul.2015.04.013

Hall, K., Paramor, O.A.L., Robinson L.A., Winrow-Giffin, A., Frid C.L.J., Eno, N.C., Dernie, K.M., Sharp, R.A.M., Wyn, G.C.& Ramsay, K. 2008. Mapping the sensitivity of benthic habitats to fishing in Welsh waters- development of a protocol. CCW [Policy Research] Report No: [8/12], 85pp.

Kochmann J, Carlsson J, Crowe TP, Mariani S (2012) Genetic evidence for the uncoupling of local aquaculture activities and a population of an invasive species—a case study of Pacific oysters (Crassostrea gigas). Journal of Hereditary 103:661–671

Kochmann, J. F. O'Beirn, J. Yearsley and T.P. Crowe. 2013. Environmental factors associated with invasion: modeling occurrence data from a coordinated sampling programme for Pacific oysters. Biological Invasions DOI 10.1007/s10530-013-0452-9.

Marine Institute (2013). A risk assessment framework for fisheries in natura 2000 sites in Ireland: with case study assessments. Version 1.3. Marine Institute, Rinville, Oranmore, Galway, 31pp.

Marine Institute (2013). A risk assessment framework for fisheries in natura 2000 sites in Ireland: with case study assessments. Version 1.3. Marine Institute, Rinville, Oranmore, Galway, 31pp.

McKindsey, CW, Landry, T, O'Beirn, FX & Davies, IM. 2007. Bivalve aquaculture and exotic species: A review of ecological considerations and management issues. Journal of Shellfish Research 26:281-294.

National Research Council, 2010. Ecosystems Concepts for Sustainable Bivalve Culture. National Academy Press, Washington, DC.

NPWS. 2009 Threat Response Plan: Otter (2009-2011). National Parks & Wildlife Service, Department of the Environment, Heritage & Local Government, Dublin.

NPWS. 2012a. Conservation Objectives for Bannow Bay SAC (Site code: 000697). Version 1.0. Department Arts, Heritage and the Gaeltacht. Version 1 (09 July, 2012); 22pp.

NPWS. 2012b. Bannow Bay SAC (Site code: 000697) Conservation objectives supporting document - coastal habitats. Department Arts, Heritage and the Gaeltacht. Version 1 (February 2012); 146pp.

NPWS. 2011. Bannow Bay SAC (Site code: 000697) Conservation objectives supporting document - marine habitats. Department Arts, Heritage and the Gaeltacht. Version 1 (November 2011); 14pp.

O'Beirn, F.X., C. W. McKindsey, T. Landry, B. Costa-Pierce. 2012. Methods for Sustainable Shellfish Culture. 2012. pages 9174-9196 In: Myers, R.A. (ed.), Encyclopedia of Sustainability Science and Technology. Springer Science, N.Y.

O'Carroll J, Quinn C, Forde J, Patterson A, O'Beirn F.X, Kennedy R. 2016. Impact of prolonged storm activity on the Ecological Status of intertidal benthic habitats within oyster (*Crassostrea gigas*) trestle cultivation sites. Marine Pollution Bulletin 110:460-469.

Roberts, C., Smith, C., Tillin, H., Tyler-Walters, H. 2010. Evidence. Review of existing approaches to evaluate marine habitat vulnerability to commercial fishing activities. Report SC080016/R3. Environment Agency,UK. ISBN 978-1-84911-208-6.

Tillin, H.M., Hiddink, J.G., Jennings, S and Kaiser, M.J. 2006. Chronic bottom trawling alters the functional composition of benthic invertebrate communities on a sea basin scale. Marine Ecology progress Series, 318, 31-45.