Castlemaine Harbour SPA

Appropriate Assessment Report of Shellfish Culture

MARINE INSTITUTE

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Prepared by STLO & TFO

Verified by TFO

Approved by STLO

Contents

Executive Summary

Shellfish culture in Castlemaine Harbour Special Protection Area (SPA) currently consists of 31 licenced sites for intensive oyster culture, one licenced site for extensive oyster culture, 16 licenced sites for mussel culture and one pending licence decision site for extensive mussel rope and bottom mussel culture. At present there are also 34 pending licence applications for extensive oyster culture, one pending licence application for extensive mussel culture and two pending licence variations (i.e. from mussel culture to intensive oyster culture). In addition to the existing and pending licences there are 13 licence applications for new areas of intensive oyster culture and one new licence applications for extensive mussel culture and one new licence for extensive mussel rope culture.

Shellfish culture is not directly connected with or necessary to the management of Castlemaine Harbour SPA. Under Section 6 of the Fisheries (Amendment) Act, 1997 (as amended), it is illegal to engage in aquaculture without an appropriate Aquaculture Licence. Driven by the need to assess the implications of licence applications for shellfish culture on Castlemaine Harbour SPA, this report has been produced in advance of the Appropriate Assessment to enable the Marine Institute to assess the potential for an adverse effect on the integrity of Castlemaine Harbour SPA, alone or in combination with other plans or projects.

The potential impact of aquaculture activities on Castlemaine Harbour SPA previously assessed by the Marine Institute and include:

Changes in invertebrate communities found in inter-tidal and sub-tidal habitats
- Habitat smothering;
- Changes in turbidity/ sediments;
- Changes in oxygen levels;
- Introduction of non-native species;
- Abrasion/Physical disturbance/Compaction;
- Displacement or relocation of prey species;
- Selective extraction of target species; and
- Selective extraction of non-target species.

Spatial proximity of special conservation interest features
- Noise/visual disturbance; and
- Displacement.

In consideration of the licence applications (new and pending) and licence variations (pending) alone and cumulatively, likely significant effects have been identified for:
- Noise/visual disturbance for all intertidal SCIs and cormorant;
- Displacement for all intertidal foraging SCIs except greenshank and redshank.

For all diving piscivore and molluscivore SCIs (common scoter, red-throated diver, scaup and cormorant) that forage in subtidal habitats, no likely significant effects have been identified.

The licence applications (new and pending) and licence variations (pending) are therefore likely to result in:
- A reduction of functional foraging habitat area;
- Disturbance to key species; and
- A reduction in species density.

For those impacts where a likely significant effect was identified in Stage 1 Screening, further consideration of the impacts on the integrity of Castlemaine Harbour SPA, alone, cumulatively or in combination with other activities, projects or plans, was made with respect to the site's structure and function and its conservation objectives.

The assessment of the impacts against conservation objectives of the Castlemaine Harbour SPA concluded that no adverse effect on site integrity, alone, cumulatively or in combination will occur for the two pending licence variation applications and one new application for subtidal mussel rope culture. These reasons for this conclusion are:

- The spatial extent of the existing and variation sites has not changed;
- The predicted impact for one new subtidal mussel rope culture application site is not appreciable and is spatially and temporally separated from other sources of disturbance; and
- The baseline level of disturbance is considered therefore to be the same as that described by National Parks and Wildlife Service.

More defined impact predictions are required in relation to new and pending licence applications alone and cumulatively. An adverse effect cannot therefore be excluded for all other licence applications alone or cumulatively because, if consented they would:

- Cause delays and interrupt progress towards achieving the conservation objectives of the site for those species in long term population decline;
- Disrupt those factors that help to maintain the favourable conditions of the site (i.e. spatial extent of functional habitat);
- Interfere with the distribution and density of SCIs that are the indicators of the favourable condition of the site (i.e. caused be displacement);
- Cause changes to the vital defining aspects (i.e. undisturbed foraging areas and an absence of obstructions to sight lines) that determine how the site functions as a supporting habitat for waterbirds;
- Reduce the area of key habitats;
- Result in disturbance that could affect population size or density or the balance between key species;
- Result in habitat fragmentation; and
- Result in loss or reduction of key features (i.e. an absence of obstructions to sight lines).

Further ornithological studies are recommended to allow for more defined impact predictions to be made in relation to the impacts predicted for new and pending licence applications. Potential mitigation options are outlined in the report.

Whilst taking into account the existing licenced sites as part of baseline conditions, only the two licence variation applications and one new application for subtidal mussel rope culture could be consented at this time. No further consenting of licence applications should take place until such time that additional studies are completed and mitigation approaches considered. The pending application decision site for combined rope mussel seed capture and bottom mussel cultivation can be consented at this time only if bottom mussel cultivation is not included in the application.

1 Introduction

1.1 Overview

This report has been prepared by NIRAS Consulting Limited for the Marine Institute and presents specialist ornithological advice to support an Appropriate Assessment of proposed aquaculture developments in Castlemaine Harbour SPA.

In accordance with Article 6(3) of the Habitats Directive, an Appropriate Assessment is required where a plan or project not directly connected with or necessary to the management of a Natura 2000 site(s), may give rise to significant effects upon a Natura 2000 site(s). The requirement for an Appropriate Assessment has been transposed into Irish law under the European Communities (Birds and Natural Habitats) Regulations 2011 (as amended).

The Department of the Environment, Heritage and Local Government (DEHLG) 'Appropriate Assessment of Plans and Projects in Ireland Guidance for Planning Authorities' (DEHLG, 2010), defines HRA as a step by step process which involves:

- Stage 1 – Screening: Determination of likely significant effects on a Natura site(s) (alone or in combination with other projects or plans);
- Stage 2 – Appropriate Assessment (AA): Assessment of implications of identified LSEs on the conservation objectives of a Natura 2000 site(s) to ascertain whether the proposal will adversely affect the integrity of a Natura 2000 site(s);
- Stage 3 – Assessment of Alternatives (where it cannot be ascertained that the proposal will not adversely affect the integrity of a European site alternative solutions; and
- Stage 4 – Assessment of Imperative Reasons of Overriding Public Interest (IROPI) (where no alternatives are identified).

Shellfish culture is not directly connected with or necessary to the management of Castlemaine Harbour SPA. Under Section 6 of the Fisheries (Amendment) Act, 1997 (as amended), it is illegal to engage in aquaculture without an appropriate Aquaculture Licence. Aquaculture licensing is administered through the Aquaculture and Foreshore Management Division of the Department of Agriculture, Food and the Marine (DAFM). The Minister for Agriculture, Food and the Marine, as the competent authority, decides on applications made to DAFM and must demonstrate before authorising a plan or project that there will be no adverse effects on the integrity of any Natura 2000 site. The requirement to demonstrate no adverse effect on site integrity also applies to authorised aquaculture developments where new aspects are introduced or management is changed (e.g. intensification) (European Commission, 2012).

Driven by the need to assess the implications of licence applications for shellfish culture on Castlemaine Harbour SPA, this report has been produced in advance of the Appropriate Assessment to enable the Marine Institute to assess the potential for an adverse effect on the integrity of Castlemaine Harbour SPA, alone or in combination with other plans or projects.

This assessment is based on a desktop review of exiting information available in the public domain and supplied by the Marine Institute. Where relevant this report identifies knowledge gaps that introduce uncertainty into the conclusions of the assessment.

1.2 Structure of this report

The structure of this report is as follows:

- Section 2 describes the methodology used for the assessment;
- Section 3 lists the Special Conservation Interests (SCIs) of Castlemaine Harbour SPA and describes the Conservation Objectives, attributes and targets, that have been defined for the SCIs and 'wetlands and waterbirds';

- Section 4 contains a risk-based screening assessment that screens out SCIs that are not vulnerable to the direct and indirect impacts of the activities being assessed;
- Section 5 contains a brief summary of the status and distribution of the SCI species, and their habitats, in the Castlemaine Harbour SPA. This section only contains a very brief summary of distribution patterns; detailed analyses of distribution patterns of SCIs is carried out where relevant in Section 9;
- Section 6 describes the current and proposed future extent of intertidal aquaculture activity and the nature of its operations;
- Section 7 identifies the potential impact of intertidal aquaculture on waterbirds;
- Section 8 presents the Stage 1 Screening assessment of likely significant effects from intertidal aquaculture in Castlemaine Harbour on the SCIs; and
- Section 9 presents the Stage 2 Appropriate Assessment of the impacts from intertidal aquaculture in Castlemaine Harbour, alone or in combination, on the SCIs of Castlemaine Harbour SPA.

1.3 Constraints to this assessment

The spatial extents of the consented and application sites and land access routes have been derived from shapefiles supplied by the Marine Institute (dated 2017 and 2019).

Detailed information on intertidal aquaculture activities such as trestle density was not available at the time of writing. Recent information on tidal dynamics is not known to exist and was therefore not available at the time of writing. In the absence of this information it was not possible to refine the area within each existing and proposed licence site where shellfish culture is technically feasible. Applying the precautionary principle, it is assumed that it is technically feasible to culture shellfish in the entire spatial extent of a consented or application site.

The I-WeBS dataset for Castlemaine Harbour (2005/06–2014/15 and 2015/16–2016/17) supplied by the Marine Institute include some incomplete count data in some years. I-WeBS data is collected within three hours either side of high tide (BirdWatch Ireland, 2009) and is therefore useful for the determination of population trends and habitat use at this part of the tidal cycle when bird densities are higher as a result of a reducing area of exposed intertidal habitat. Husbandry of intertidal shellfish generally occurs within two or three hours either side of low tide and therefore I-WeBS data is not appropriate for the determination of impact significance of most intertidal shellfish culture activities when bird densities are lower as a result of an increasing area of exposed intertidal habitat. Long term, since baseline (2009/10–2016/17) and short term (2012/13–2016/17) population trends using I-WeBS data are used in this report. The location of high tide roosts has been published by NPWS (2011a) and covers only one high tide (26 February 2010). The raw data was not available at the time of writing and as a result, the presence of significant numbers of waterbirds assigned to an individual species cannot be determined in all cases. It is not known if high tide roosts shift throughout the year and if the location of roosts have changed since February 2010.

Low tide count survey data analysis for the entire Castlemaine Harbour SPA is published by NPWS (2011a) and covers a limited period from October 2009 to February 2010. The raw data was not available at the time of writing and as a result the presence of significant numbers of waterbirds assigned to an individual species cannot be determined in all cases. The spatial extent of the low tide count sectors do not correspond to the count sectors of the I-WebS surveys because of the significant difference in the extent of exposed habitat to be surveyed between low tide and I-WeBS (high tide) counts. It is not known if the low tide abundance and distribution of waterbirds has changed since 2009/10 and if it has changed whether these changes are in line with the population trends identified from the I-WeBS data.

There is no quantitative information available on the distribution of waterbirds within Castlemaine Harbour before the introduction of aquaculture activities within Castemaine Harbour and therefore it is not possible to quantitatively assess estuary-wide impacts of the activities. There is some site-specific information on the impacts of displacement of waterbirds (light-bellied brent goose, wigeon, oystercatcher, bar-tailed godwit, turnstone) as a result of the presence of oyster trestles (Gittings & O'Donoghue, 2012).

In the absence of substantive detailed information, the assessment of in combination impacts is provided through a qualitative assessment of the cumulative effects of existing and proposed shellfish culture licence sites as well as for other activities, plan and projects. The assessment of other activities, plans and projects is informed by site-specific information published by Marine Institute (2011, 2016), NPWS (2011a) and Gittings & O'Donoghue (2012).

2 Methodology

2.1 General

This assessment is based on a desktop review of existing information on waterbird population trends and distribution in Castlemaine Harbour SPA in addition to a site familiarisation visit.

2.2 Data sources

The SPA boundaries are derived from NPWS shapefiles (which were last updated on 29/06/2017).

The spatial extents of the existing and proposed aquaculture licence sites have been derived from shapefiles supplied by the Marine Institute (dated 2017).

The waterbird data sources used for the assessment are as follows:

- Irish Wetland Bird Survey (I-WeBS) counts 2002/03–2016/17;
- Long term and short term population trends for Castlemaine Harbour SPA (Marine Institute, 2016; BirdWatch Ireland, 2019a);
- Long term and short term national waterbird population trends (BirdWatch Ireland, 2019b);
- The descriptions of low tide and high tide waterbird distribution within Castlemaine Harbour in the SPA Conservation Objectives Supporting Document (NPWS, 2011a); and
- Data collected during the oyster trestle study (Gittings and O'Donoghue, 2012).

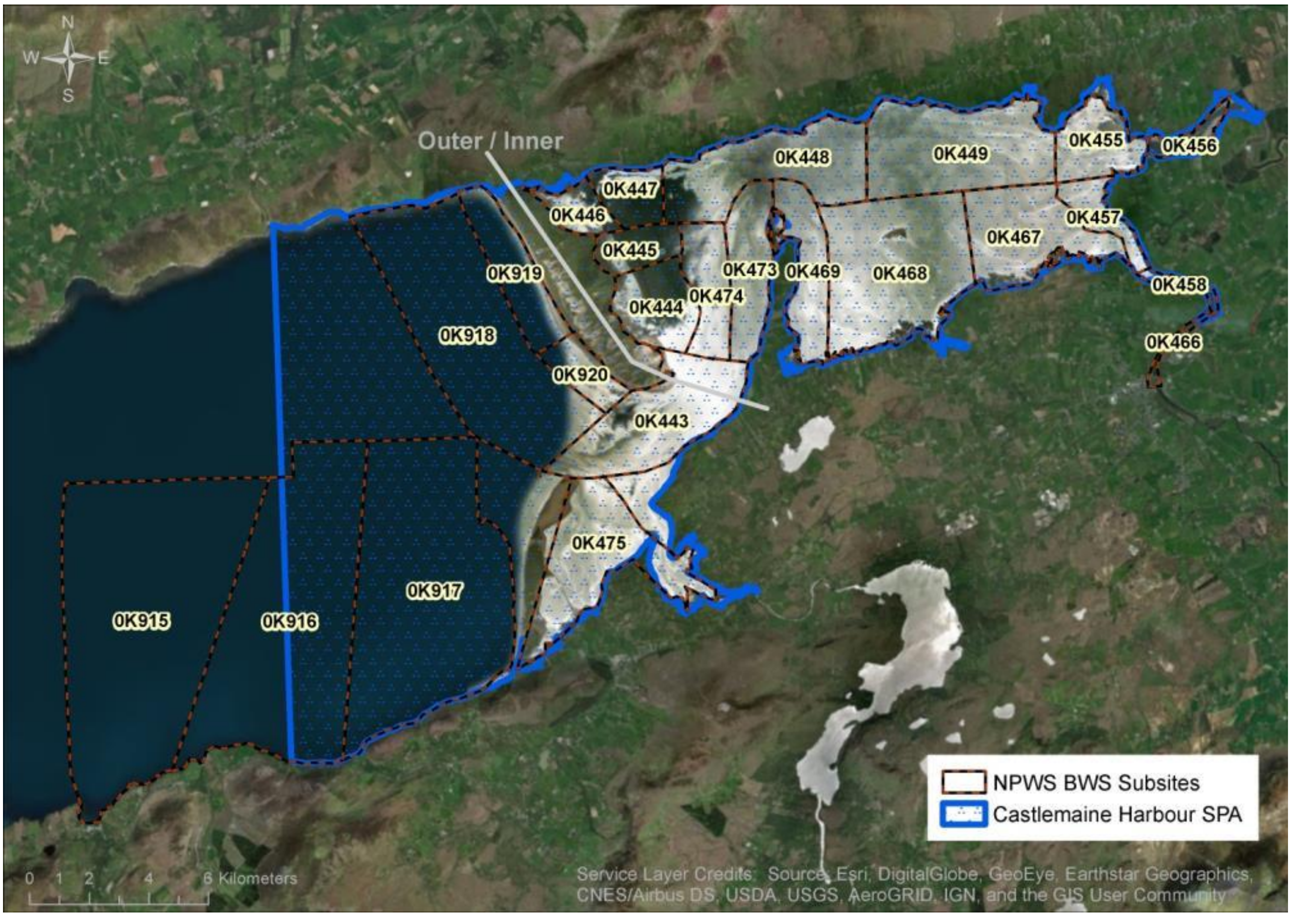
The spatial extents of the habitats and biotopes have been derived from shapefiles supplied by the Marine Institute (undated).

Information on other activities was obtained primarily from previous appropriate assessments of Castlemaine Harbour SPA (Marine Institute 2011, 2016) as well as from NPWS (2011a) and the oyster trestle study (Gittings and O'Donoghue, 2012).

2.3 Subsites

Castlemaine Harbour was divided in 24 subsites for the NPWS Baseline Waterbid Survey (BWS) and these subsites (or amalgamations of some of these subsites) correspond with I-WeBS count sectors. For the purposes of analysing SCI distribution, the subsites have been divided into two broad zones: inner Castlemaine Harbour and outer Castlemaine Harbour (Figure 2.1). For the purposes of this assessment, the inner harbour is differentiated from the outer harbour by a centre line along the Inch Strand such that intertidal habitats in the outer harbour are dominated by fine sands and inner harbour is dominated by muds.

Figure 2.1: Castlemaine Harbour SPA NPWS BWS (low tide) subsites



2.4 Definition of habitat zones

Three broad habitat zones have been defined for this assessment: supratidal, intertidal and subtidal (Figure 2.2). The biotope map (Figure 2.3) shows the approximate boundaries between the intertidal and subtidal zones, i.e. the lower limits of the mapped biotopes. The actual extent of tidal exposure is not known at the time of writing.

Figure 2.2: Distribution of broad habitat types in Castlemaine Harbour SPA

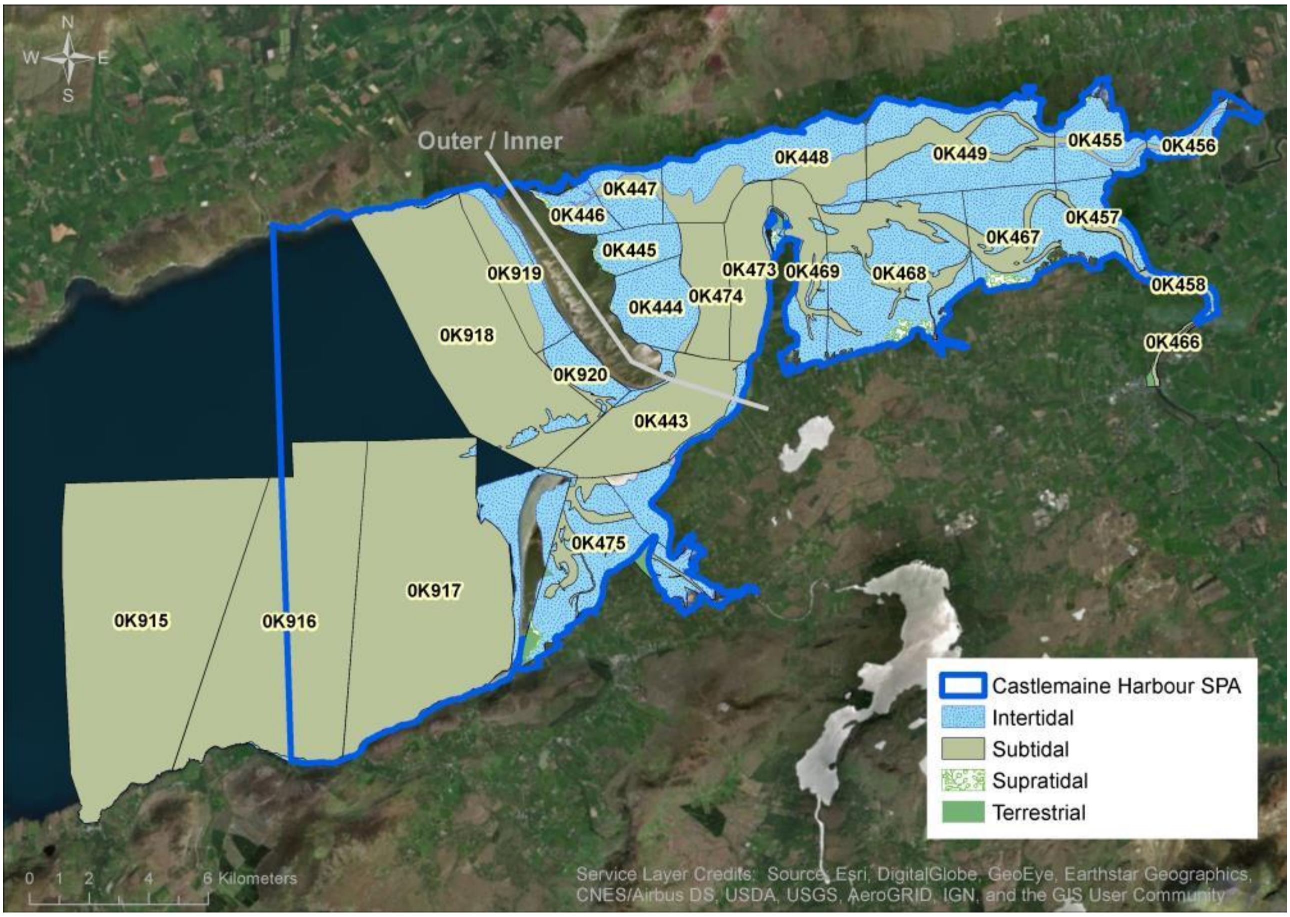
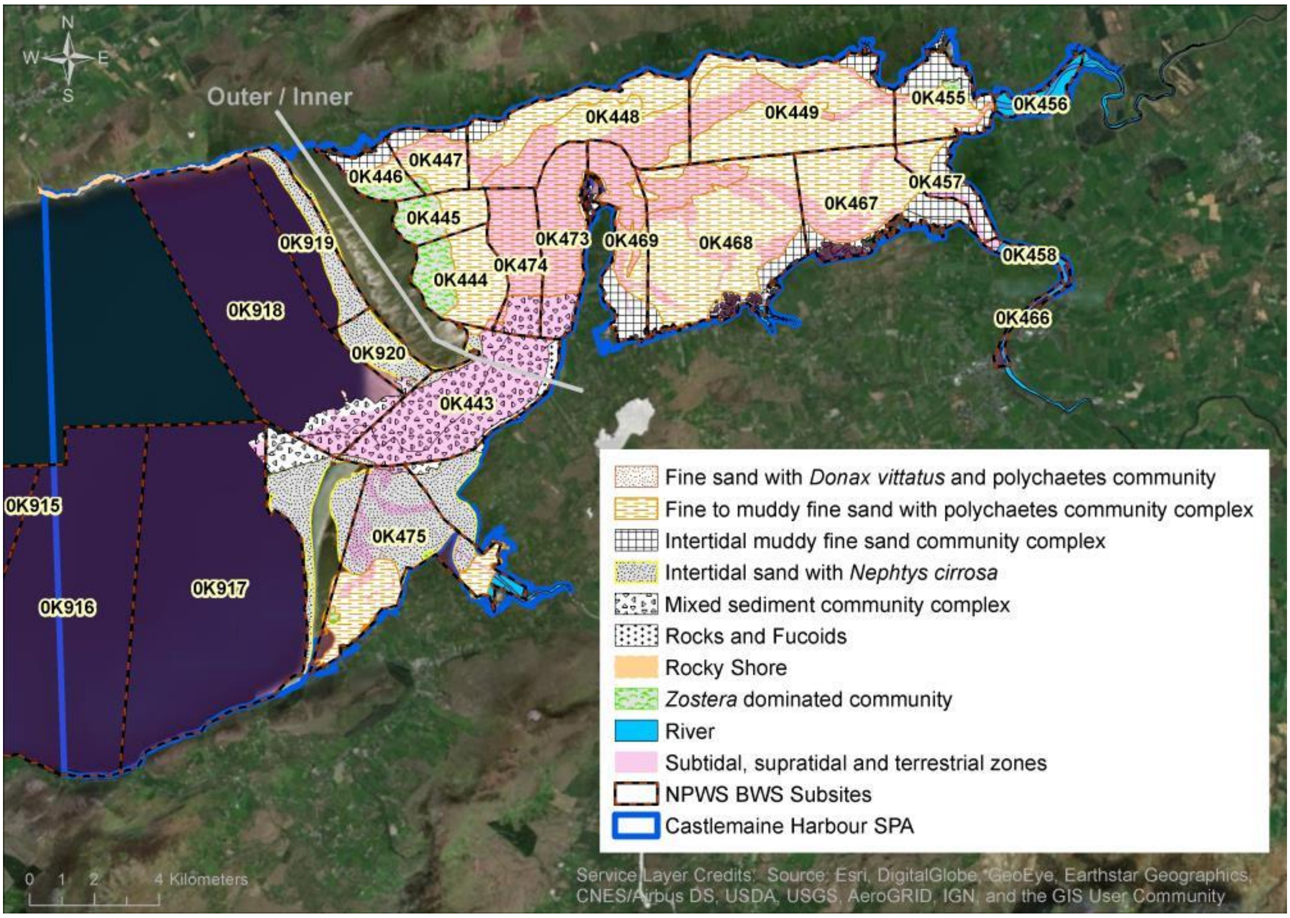


Figure 2.3: Distribution of biotopes in Castlemaine Harbour SPA



2.5 Analyses of waterbird distribution

Previous appropriate assessments of aquaculture activities in Castlemaine Harbour SPA identified the availability and/or quality of feeding habitat as a key determining factor in the maintenance of site integrity with respect to the conservation objectives (Marine Institute, 2011; 2016). The analyses of waterbird distribution in this assessment therefore focuses on the distribution patterns of SCIs at low tide because the distribution of waterbirds at this part of the tidal cycle best reflects the usage of foraging habitats within the SPA.

High tide roost sites in supratidal and terrestrial locations will not typically be impacted by activities related to shellfish culture. Where an impact may occur, i.e. from the location of land access routes, the potential impacts are assessed.

SCI distribution has been analysed by reviewing the analysis of data across subsites from the NPWS BWS (NPWS, 2011a) and trestle study (Gittings and O'Donoghue, 2012).

2.6 I-WeBS

"I-WeBS aims to monitor all nonbreeding waterbirds in Ireland to provide the principal data on which the conservation of their populations and wetland habitats is based" (BirdWatch Ireland, 2009). The scheme has surveyed Castlemaine Harbour every winter since 1994/95 (Marine Institute, 2016; p. 60) although coverage of the site varies from year to year and incomplete counts occurred regularly prior to the winter of 2010/11.

Analysis of I-WeBS data for the purposes of determining population trends at Castlemaine Harbour SPA was conducted by the Marine Institute (2016). This existing data analysis was used in the report coupled with the analysis of national trends published by BirdWatch Ireland (2018). A comparative assessment of long term and short term trends was undertaken to identify if site-specific drivers of population change were likely to be operating in Castlemaine Harbour SPA. Where the a negative population trend of an SCI in Castlemaine Harbour SPA was greater than the national trend it was considered likely that conditions within the SPA were in part driving the decline (Cook *et al*., 2013; Gittings & O'Donoghue, 2014).

2.7 NPWS BWS

In the winter of 2009/10, four coordinated low tide and one high tide count were carried out in all 24 subsites from land-based vantage points. A separate high tide roost survey was carried out on one date in February 2010. Each count was completed in a single day and there was complete coverage on each count (NPWS, 2011a).

Analysis of NPWS BWS data for the purposes of determining population trends at Castlemaine Harbour SPA was conducted by the NPWS (2011a). This existing data analysis was used in the report to:

- Identify subsites of relative importance to foraging waterbirds in Castlemaine Harbour SPA (low tide count analysis);
- Indicate the relationships between species distributions and broad topographical/habitat zones (flock maps);
- Identify locations supporting significant numbers of roosting waterbirds (roost location maps and data table); and
- Identification and qualification of disturbance events and activities.

2.8 Trestle study

Castlemaine Harbour was included in a study carried out of the relationship between intertidal oyster cultivation and waterbird distribution (Gittings & O'Donoghue, 2012). The study area comprised of 1391 ha or 32% of the 4287 ha of the mudflats and sandflats not covered by seawater at low tide in Castlemaine Harbour SPA and a large proportion of the total intertidal area of the intertidal fine to muddy fine sand with polychaetes community complex (Gittings & O'Donoghue, 2012).

The study site was located along the southern side of Castlemaine Harbour, between Cromane Point and Douglas Strand and was divided into five sectors, defined by biotope type Counts were carried out on four dates in January and February 2011 during spring low tide conditions when the exposure of the oyster trestles was maximal (Gittings & O'Donoghue, 2012).

2.9 Assessment methodology

2.9.1 Stage 1 Screening

2.9.1.1 General approach

The Stage 1 Screening will:

1) Describe the individual elements of each licence application (either alone or in combination with other licence applications, plans or projects) likely to give rise to impacts on Castlemaine Harour SPA
2) Describe any likely direct, indirect or secondary impacts of the licence applications (either alone or in combination with other licence applications, plans or projects) on Castlemain Harbour SPA by virtue of:
   - size and scale;
   - land-take;
   - distance from Castlemaine Harbour SPA or key features of the site;
   - resource requirements (water abstraction etc.);
   - emissions (disposal to land, water or air);
   - excavation requirements;

- transportation requirements; and
- duration of construction, operation, decommissioning, etc.;

3) Describe any likely changes to the site arising as a result of:
   - reduction of habitat area:
   - disturbance to key species;
   - habitat or species fragmentation;
   - reduction in species density;
   - changes in key indicators of conservation value (water quality etc.); and
   - climate change.
4) Describe any likely impacts on the Natura 2000 site as a whole in terms of:
   - interference with the key relationships that define the structure of the site; and
   - interference with key relationships that define the function of the site.
5) Provide indicators of significance as a result of the identification of effects set out above in terms of:
   - loss;
   - fragmentation;
   - disruption;
   - disturbance; and
   - change to key elements of the site (e.g. water quality etc.).
6) Describe from the above those elements of each licence application, or combination of elements, where the above impacts are likely to be significant or where the scale or magnitude of impacts is not known.

2.9.1.2 Determination of likely significant effects

Our approach is an adapted version of a method developed by the Centre for Ecology and Hydrology in the UK as part of a joint Ramsar and WWF led initiative (Stratford *et al*., 2011). Together with baseline information, this vulnerability assessment methodology delivers the information needed for establishing strategies, policies and management interventions to maintain the integrity of Castlemaine Harbour SPA. The method developed by Stratford *et al*. (2011) satisfies the elements of the vulnerability assessment framework described by Gitay *et al*. (2011) and represents a specific tool developed for site specific assessments of vulnerability.

The risk assessment applies a four step assessment:

- Step 1: Identification and scoring of SCIs.
- Step 2: Identification and scoring of potential impacts to SCIs.
- Step 3: Links between SCIs and potential impacts.
- Step 4: Vulnerability assessment.

The output of combining the Steps 1 to 3 of the assessment process produces the final assessment of vulnerability (Step 4). The final assessment forms the basis for screening species and subsites in or out of the Appropriate Assessment and the determination of adverse effect on site integrity.

2.9.1.2.1 Step 1: SCIs

For each SCI, an attribute score was assigned by multiplying two species-specific attribute scores. The two attributes used to score SCIs were amended from that published in Stratford *et al* (2011). Attribute 1 scoring was based on the baseline importance of the SCI population (subnational [1], national [2], international [3]). Attribute 2 scoring was based on current conservation status (favourable [1], intermediate/moderate unfavourable [2], highly unfavourable [3]).

2.9.1.2.2 Step 2: Potential Impacts on SCIs

The potential impacts in relation to each of the SCIs were identified and described with additional supporting evidence from peer-reviewed literature and from consultation with technical experts within the company.

For each of the impact Stratford *et al*. (2011) applies a matrix (Table 2.1) to combine the scores for the severity of the impact and the likelihood of impact. The impact score was then used in the risk assessment. Where there is no likelihood of an impact occurring the value is assigned a score of zero.

Likelihood	Severity		
	1 (Low)	2 (Medium)	3 (High)
1 (Low)	1 (Low)	1 (Low)	2 (Medium)
2 (Medium)	1 (Low)	2 (Medium)	3 (High)
3 (High)	2 (Medium)	3 (High)	3 (High)

Table 2.1: Impact score matrix

2.9.1.2.3 Step 3: Links between SCIs and impacts (impact pathways)

Each potential interaction between a SCI and an impact is assigned a score between one and three, or no score (zero) where there are no interactions. Potential impacts, in respect of their size, amount, intensity, volume and duration, were assigned link scores on the following basis:

- High (3) = may be considered to have a long term, direct or indirect impact of moderate to major magnitude.
- Medium (2) = may be considered to have a medium to short term, direct or indirect impact of minor to moderate magnitude.
- Low (1) = may be considered to have direct or indirect impact of any duration but with no appreciable effect.
- None (0) = may be considered to have no impact link with the SCI.

As previously determined, impact pathways were established on the basis of the spatial overlap between the SCI and the proposed aquaculture activities (Marine Institute, 2011, p. 26). Since the previous Marine Institute appropriate assessments (2011; 2016) no new SCIs have been legally cited. Licence applications for mussel culture using ropes will introduce a new culture method to Castlemaine Harbour although the culture practices are not appreciably different from existing shellfish activities when also considering the seed mussel fishery.

The impact pathways identified by the Marine Institute (2011, p. 23) therefore remain the same and include:
- Changes in invertebrate communities found in inter-tidal and sub-tidal habitats; and
- Spatial proximity of SCIs.

2.9.1.2.4 Step 4: Vulnerability assessment

Following the completion of the three assessment steps described above, the following formula was applied to each qualifying feature:

SCI Score × Link Score × Impact Score = Final Risk Assessment Value

The final assessment value, the risk of an impact having a significant effect a SCI is subdivided into three risk categories: Low (<16), Medium (16–27) and High (≥27).

The determination of likely significant effect is based on assumptions which introduce a high degree of precaution in the absence of specific detailed proposals from licence applicants and scientific uncertainty with regards to the direction and magnitude of a species' population response to a potential impact. The precaution allows the competent authority to apply the precautionary principle as defined in the 'Communication from The Commission on the precautionary principle' (European Commission, 2000). The assumptions underpinning the determination of likely significant effect are:

1) The entire spatial extent of each licence application site will be subject to shellfish culture activities; and
2) The potential impacts for SCIs with high and moderate vulnerability are considered likely to be significant.

2.9.2 Identification of potential impacts

The potential impacts of intertidal aquaculture activities on Castlemaine Harbour SPA were previously assessed by the Marine Institute (2011, p. 24; 2016, p. 87–89) and include the following:

Changes in invertebrate communities found in inter-tidal and sub-tidal habitats

- Habitat smothering;
- Changes in turbidity/ sediments;
- Changes in oxygen levels;
- Introduction of non-native species;
- Abrasion/Physical disturbance/Compaction;
- Displacement or relocation of prey species;
- Selective extraction of target species; and
- Selective extraction of non-target species.

Spatial proximity of special conservation interest features

- Noise/visual disturbance.

Displacement of SCIs from aquaculture sites as a result of the presence of oyster trestles was not previously assessed at Castlemaine Harbour SPA (Marine Institute, 2011). This potential impact has been included in this Appropriate Assessment because of the evidence of a measurable effect on Castlemaine Harbour SCIs and is likely to be significant in some situations (Gittings & O'Donoghue, 2012; 2014; 2017).

2.9.3 Determination of likely significance effect

Based on the outcomes of the vulnerability assessment (Section 2.9.1.2.1–2.9.1.2.4) likely significant effects were identified for all SCIs that have a medium to high vulnerability to a potential impact, i.e. the degree to which an SCI is sensitive to and unable to adapt to or moderate the consequences of an impact.

For those impacts where a likely significant effect was conclude, the impact and only those vulnerable SCIs were taken forward for further assessment in the Stage 2 Appropriate Assessment.

2.9.4 Stage 2 Appropriate Assessment

2.9.4.1 *Determination of* adverse *effect on site integrity*

For those impacts where a likely significant effect was identified in Stage 1 Screening, further consideration of the impacts on the integrity of Castlemaine Harbour SPA, alone, cumulatively or in combination with other activities, projects or plans, was made with respect to the site's structure and function and its conservation objectives (European Communities, 2002).

The impact prediction is based on a spatial analysis of licence application sites in relation to subsites of known importance to SCIs and existing levels of threat from other activities, projects and plans identified as part of the desktop review. The spatial analysis was undertaken using ArcMap 10.5 (Environmental Systems Research Institute [ESRI], 2016). Together with evidence in the published literature a determination of adverse effect on site integrity was made in relation to the conservation objectives of Castlemaine Harbour SPA.

In relation to cumulative and in combination effects, there are two potential approaches to summing the predicted impacts of the individual licence applications ; an 'all-projects' approach and a 'building blocks approach'. For comparison, both approaches are used in the assessment of adverse effect. In an 'all-projects' approach no single licence application site has supremacy over another. In a building blocks approach the existing consents are given supremacy in a tiered system, as follows:

- Tier 1 – existing consented licences;
- Tier 2 – pending licence variation applications; and
- Tier 3 – all new and pending applications.

At the time of writing there is no agreed position on determining the order of Tier 3 applications and the details of licence submission timing was not available. Tier 3 applications would typically be assessed in the chronological order the applications were submitted, i.e. to be assessed and consented on a first come, first serve basis until an adverse effect is concluded. In this assessment Tier 3 applications were considered with equal weighting.

Where an adverse effect on site integrity could not be excluded alone, cumulatively or in combination, an assessment of the potential mitigation of those impacts was considered.

3 Conservation objectives

3.1 Overview

"The overarching Conservation Objective for Castlemaine Harbour SPA is to ensure that waterbird populations and their wetland habitats are maintained at, or restored to, favourable conservation condition. This includes, as an integral part, the need to avoid deterioration of habitats and significant disturbance; thereby ensuring the persistence of site integrity" (NPWS, 2011b; Table 3.1).

Objective 1 - To maintain the favourable conservation condition of the waterbird Special Conservation Interest species listed for Castlemaine Harbour SPA (NPWS, 2011b).

Objective 2 - To maintain the favourable conservation condition of the wetland habitat at Castlemaine Harbour SPA as a resource for the regularly-occurring migratory waterbirds that utilise it (NPWS, 2011b).

The favourable conservation status of a species is achieved when:

- Population dynamics data on the species concerned indicate that it is maintaining itself on a long term basis as a viable component of its natural habitats;
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future; and
- There is, and will probably continue to be, a sufficiently large habitat to maintain its population on a long-term basis (NPWS, 2011b).

Feature	Attribute	Measure	Target	Notes
SCI	Population trend	Percentage change	Long term population trend stable or increasing	Population trend assessment (Generalised Additive Modelling (GAM)) was undertaken using waterbird count data collected through the Irish Wetland Bird Survey and other surveys.
	Distribution	Number and range of areas used by waterbirds	No significant decrease in the numbers or range of areas used by waterbird species, other than that occurring from natural patterns of variation.	As determined by regular low tide and other waterbird surveys.

Wetlands & waterbirds	Habitat area	Hectares	The permanent area occupied by the wetland habitat should be stable and not significantly less than the areas of 7472, 3983 and 322 hectares for subtidal, intertidal, and supratidal habitats respectively, other than that occurring from natural patterns of variation.	Habitat area

Table 3.1: Conservation objective attributes and targets (NPWS, 2011a).

4 Status, habitats and distribution of SCIs

4.1 Waterbird status

Castlemaine Harbour SPA is one of the most suitable sites in the country for the conservation of nine SCIs ('selection species') (NPWS, 2011a). Seven 'additional species of conservation interest' are also listed together with the wetland habitats and the waterbirds that utilise this resource.

In the most recent five-year period (2012/13–2016/17) selection species occurring in internationally important numbers include light-bellied brent geese *Branta bernicla hrota* (1053) with nationally important numbers of wigeon *Anas penelope* (4033), pintail *Anas acuta* (76), ringed plover *Charadrius hiaticula* (121), sanderling *Calidris alba* (337) and bar-tailed godwit *Limosa lapponica* (335) (BirdWatch Ireland, 2019a).

Additional species of conservation interest occurring in nationally important numbers include: mallard *Anas platyrhynchos* (446), greenshank *Tringa nebularia* (37) and redshank *Tringa totanus* (724). Three of the additional species of conservation interest, cormorant *Phalacrocorax carbo* (54), oystercatcher *Haematopus ostralegus* (560), and turnstone *Arenaria interpres* (33), no longer meet or exceed their respective national population thresholds.

For common scoter, red-throated diver and scaup there are incomplete counts in one or more years. However, the Natura 2000 - Standard Data Form, updated in September 2017, indicates that data quality for these species is good (based on surveys) and that compared to baseline all three species appear to have declined. The Standard Data Form estimates for common scoter (67 individuals), red-throated diver (63 individuals) and scaup (29 individuals) represent a decline of 98%, 10% and 68% respectively with red-throated diver and scaup potentially occurring in nationally important numbers.

Five unlisted species now exceed their respective national population thresholds, including little egret *Egretta garzetta* (37) and curlew *Numenius arquata* (395). The Natura 2000 - Standard Data Form, updated in September 2017, lists a further nine species that do not regularly exceed their respective national population thresholds, these species are: shelduck Tadorna tadorna (110), teal Anas crecca (163), red-breasted merganser *Mergus serrator* (4), great northern diver *Gavia immer* (7), golden plover *Pluvialis apricaria* (122), grey plover *Pluvialis squatarola* (28), lapwing *Vanellus vanellus* (343), dunlin Calidris alpina (518), knot Calidris canutus (181), black-tailed godwit *Limosa limosa* (86), black-headed gull *Chroicocephalus ridibundus* (264), common gull *Larus canus* (18), and lesser black-backed gull *Larus fuscus* (15).

Chough *Pyrrhocorax pyrrhocorax*, is the only non-waterbird selection species. Breeding outside the SPA, this species is found in the non-breeding season feeding and socialising in the sand dunes at Inch and Rosbehy (Trewby *et al*. 2006 in NPWS, 2011a). This is species is not included in the assessment of likely significant effects below because there is no link between the impacts arising from the proposed aquaculture activities and the chough population (Marine Institute, 2011, p. 56).

Based on the most recent five year period, the populations of three species in Castlemaine Harbour are currently in highly unfavourable conservation status (>50% decline), three species are in moderate unfavourable condition (25–49% decline), one species is intermediate unfavourable condition (1–24% decline) and eight species are in favourable condition (stable or increasing) (Table 5.1). Over the longer term (since baseline), only turnstone are in unfavourable condition with wigeon, pintail, ringed plover and cormorant in intermediate or moderate unfavourable conditions.

Species	I-WeBS Population Estimate and Importance (mean of peak counts)		Population Trends (%)	
	Baseline (2009/10)	2010/11–2014/15	Since baseline 2009/10–2016/17	Five-year 2012/13–2016/17
Selection species				
Light-bellied Brent Goose	435 International	1,053 International	+142	-29
Wigeon	4,780 All-Ireland	4033 All-Ireland	-16	+153
Pintail	97 All-Ireland	76 All-Ireland	-22	+4
Common Scoter	3,043 All-Ireland	153 *Incomplete count*	↓	↓
Red-throated Diver^	70 All-Ireland	2 Incomplete count	↓	↓
Ringed Plover	127 All-Ireland	121 All-Ireland	-5	-67
Bar-tailed Godwit	190 All-Ireland	335 All-Ireland	+76	-36
Sanderling	250 All-Ireland	337 All-Ireland	+35	-50
Additional Species of conservation interest				
Mallard	370 All-Ireland	446 All-Ireland	+21	-82
Scaup	92 All-Ireland	9 Incomplete count	↓	↓
Cormorant	63 All-Ireland	54 Subnational	-14	-22
Oystercatcher	510 All-Ireland	560 Subnational	+10	-36
Turnstone	104 All-Ireland	33 Subnational	-68	-88
Greenshank	31 All-Ireland	37 All-Ireland	+19	-46
Redshank	140 All-Ireland	724 All-Ireland	+417	-75
^ Listed on Annex I of the Birds Directive. ↓ For incomplete counts arrows indicate direction of change.				

Table 4.1: Castlemaine Harbour SPA SCIs

Castlemaine Harbour is known to be subjected to disturbance activities including those from recreation and aquaculture (NPWS, 2011a). Quad bikes activities can be managed through the 'Activities Requiring Consent' (ARCs) aspect of the Natura site designation or other regulations (NPWS, 2011b) but it is not known if these have been implemented.

The site is also likely to be subjected to the impacts of climate change e.g. possible increases in rates of erosion due to currents and sedimentation (Desmond *et al.*, 2009). No conservation management plan for the SPA or the overlapping Special Area of Conservation (SAC) has been published to date.

4.2 Waterbird habitats and distribution

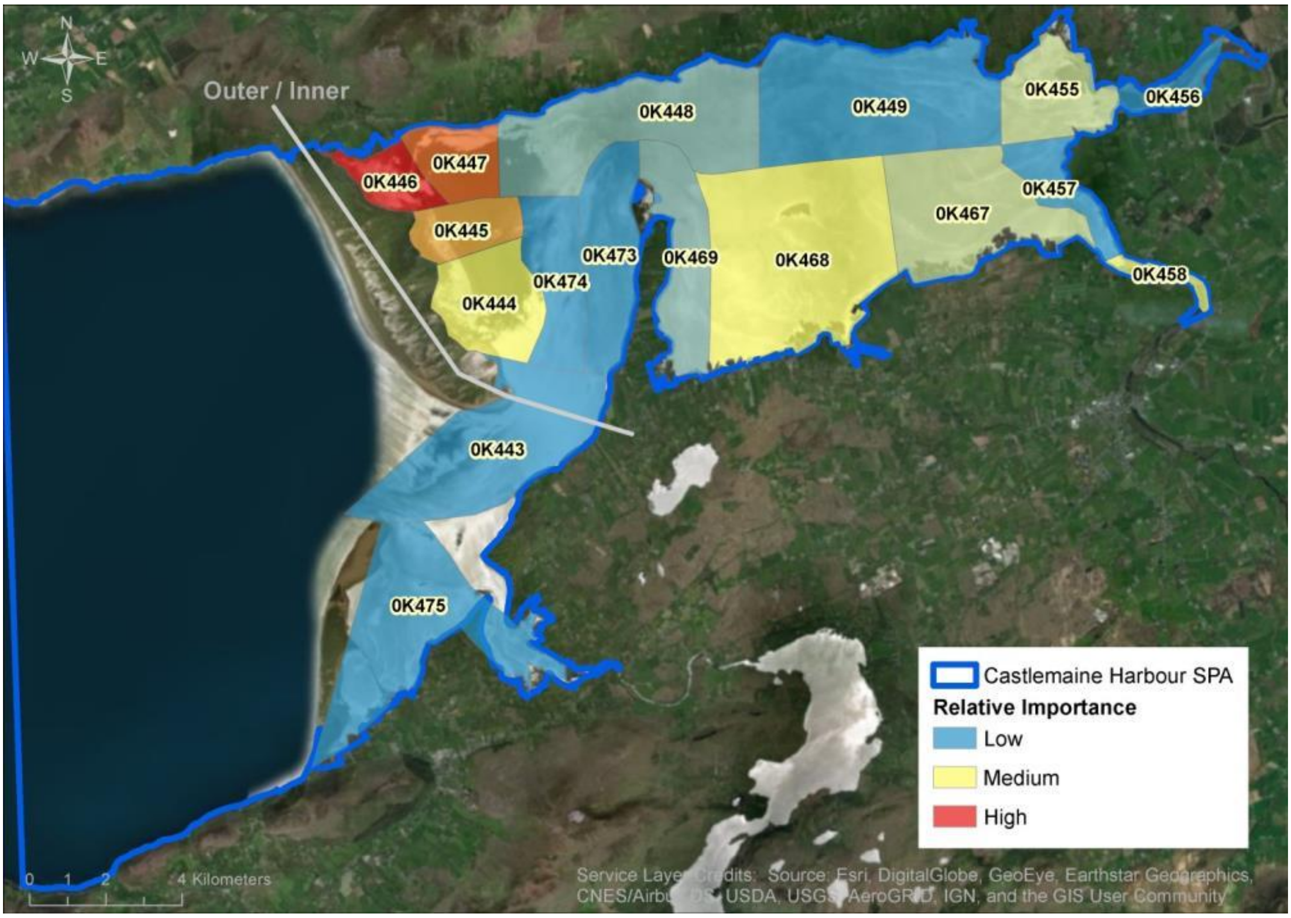
Castlemaine Harbour SPA is located on the coast of southwest Ireland in the innermost part of Dingle Bay (Figure 2.1). The SPA comprises the estuaries of the River Maine and the River Laune and is dominated by extensive areas of sheltered intertidal sand and mud flats (Figure 2.2) with fringing saltmarsh and shallow marine waters (NPWS, 2014). Intertidal eel grass beds are present on the eastern side of Inch dune system and a small patch is present in the far north eastern part of the SPA (Figure 2.3). A coastal barrier dune system at Inch and Rosbehy (Rossbeigh) provides shelter to the inner part of the SPA (NPWS, 2014). These sand spits protect the key structural and functional relationships that create and maintain the site's integrity. Whilst the Inch barrier system is relatively stable the Rossbehy system has breached in recent times with the potential to change the marine habitats behind the barrier and consequently the associated species communities they support (Marine Institute, 2015; O'Shea & Murphy, 2013).

At low tide, higher species diversity was found within subsites dominated by intertidal habitats and all subsites were considered important for at least one SCI (NPWS, 2011a). The relative importance of 10 out of the 18 intertidal subsites were considered to be notable based on the presence of significant counts or maximum or average densities of SCIs (Table 4.2; Figure 4.1). There sites are critical to maintaining SCIs in favourable condition. The intertidal area east of the Inch dune system supports important the most number of SCIs (0K447 [9 species], 0K446 [8], 0K445 [5]). The eel grass (*Zostera*) beds are particularly important for light-bellied brent geese moving to other subsites, notably 0K447, when the foraging resource is depleted (NPWS, 2011a). Subsites where no SCIs are present in such numbers or densities to be notable in relative terms may still support smaller numbers of SCIs and make some contribution to the favourable condition status of the SCIs.

SCI	Subsite																	No. of subsites
	OK443	OK444	OK445	OK446	OK447	OK448	OK449	OK455	OK456	OK457	OK458	OK467	OK468	OK469	OK473	OK474	OK475	
Light-bellied brent goose		x	x	x	x	x		x			x	x	x	x				**10**
Wigeon				x	x													**2**
Pintail				x	x													**2**
Ringed Plover			x		x							x						**3**
Bar-tailed godwit		x		x									x					**3**
Sanderling				x	x													**2**
Mallard			x	x	x													**3**
Oystercatcher		x	x	x	x								x					**5**
Turnstone				x	x						x							**3**
Greenshank											x							**1**
Redshank			x	x				x										**3**
No. of species	**0**	**3**	**5**	**9**	**8**	**1**	**0**	**2**	**0**	**0**	**3**	**2**	**3**	**1**	**0**	**0**	**0**	

Table 4.2: Notably important intertidal subsites

Figure 4.1: Relative importance of intertidal subsites



All I-WeBS subsites support significant numbers of at least one SCI in the three hours either side of high tide. High tide roosts are located mainly in the inner part of Catlemaine Harbour, with multiple large roosts concentrated on the eastern side of the Inch sand dune system (Figure 4.2–Figure 4.5).

Figure 4.2: High tide roost sites: Inch

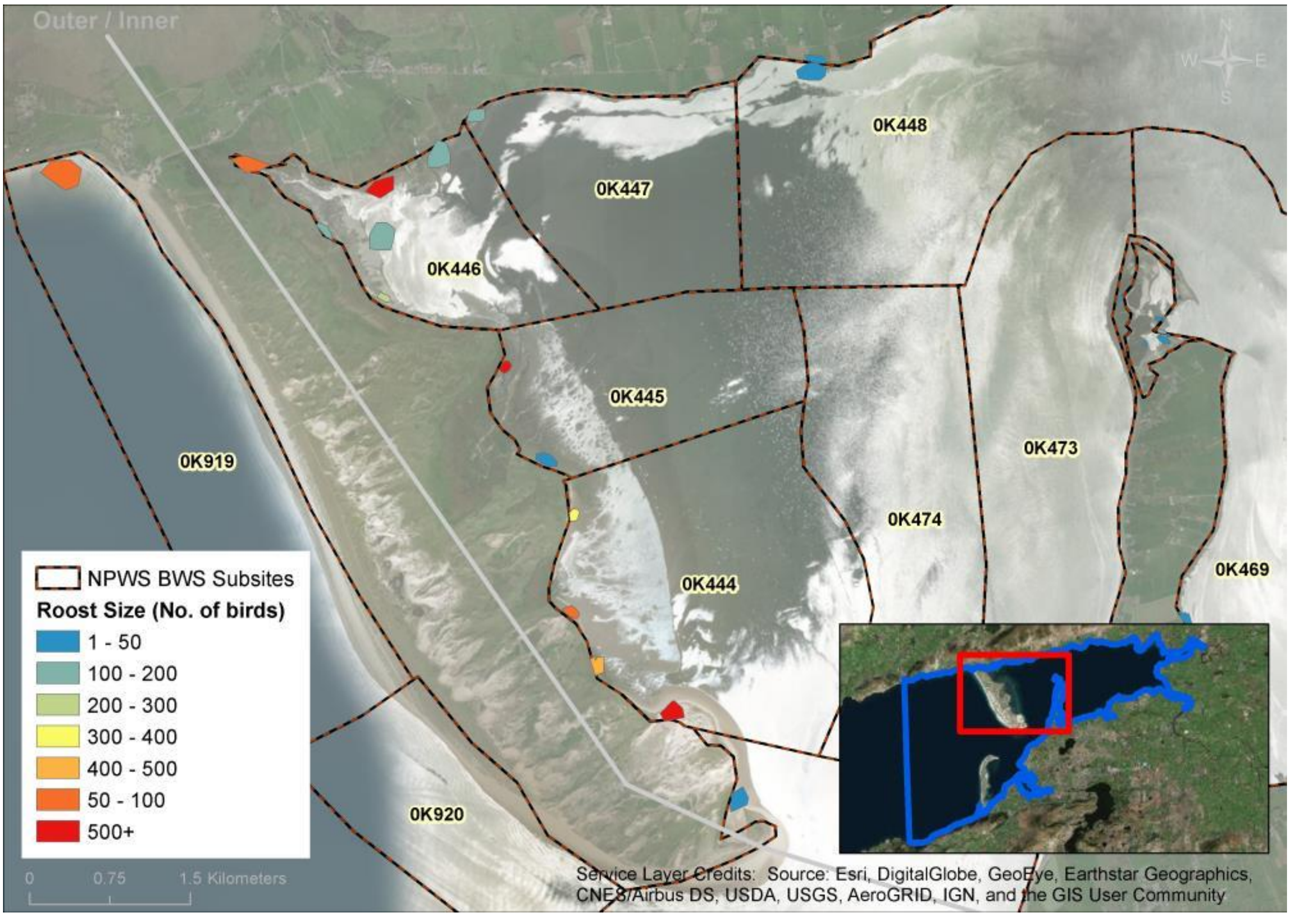


Figure 4.3: High tide roost sites: Dooks to Glenbeigh

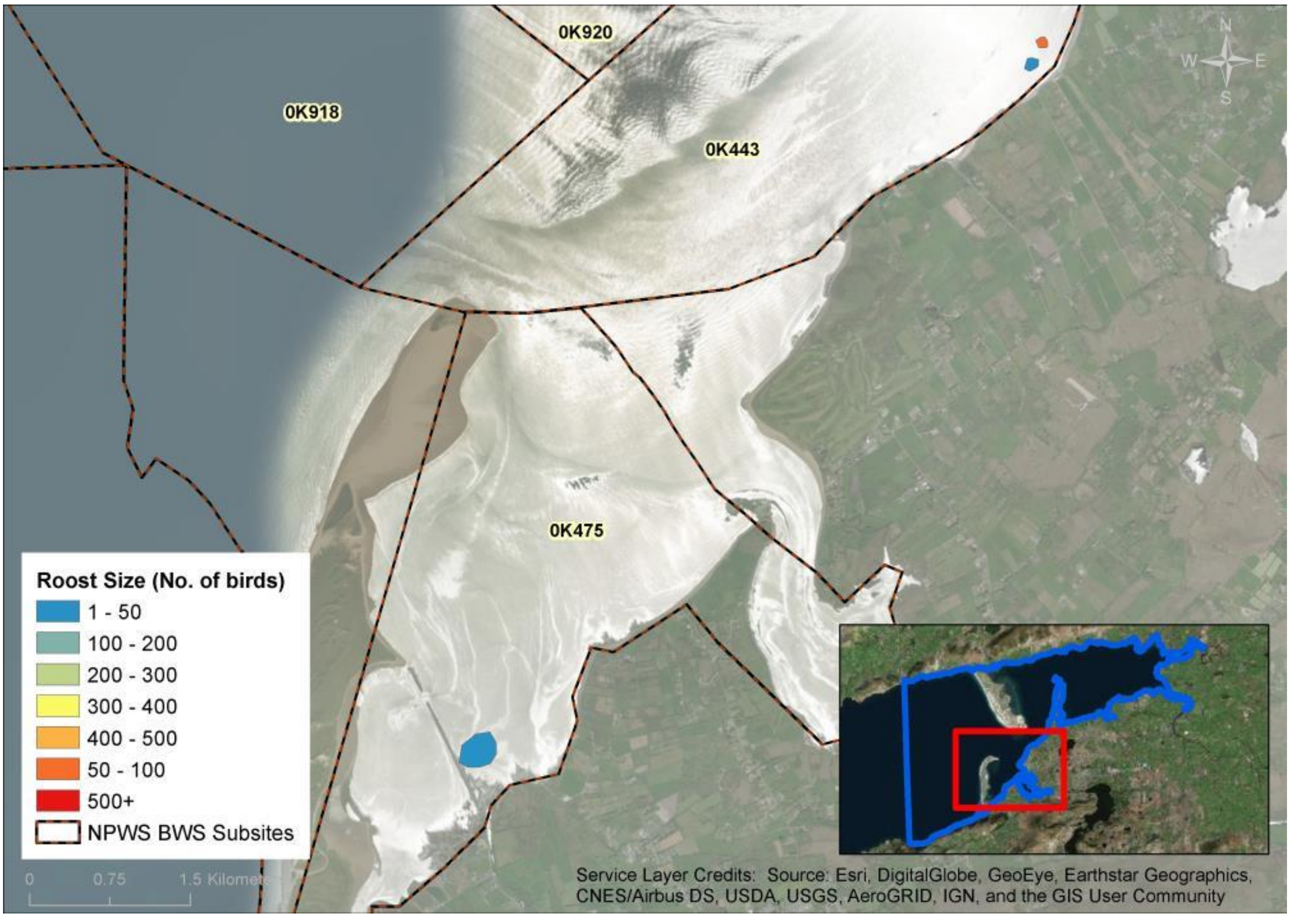


Figure 4.4: High tide roost sites: Killorglin to Cromane

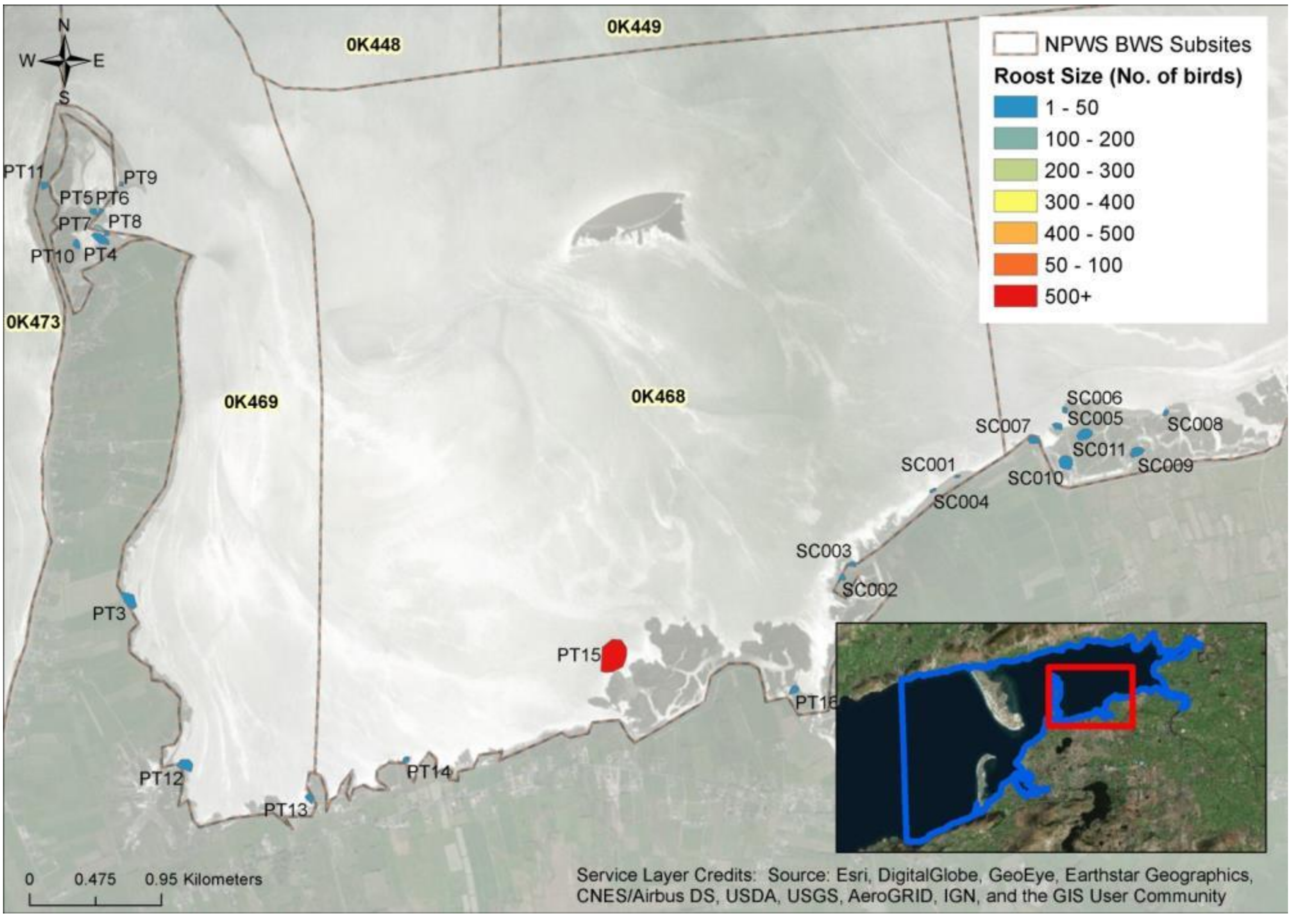
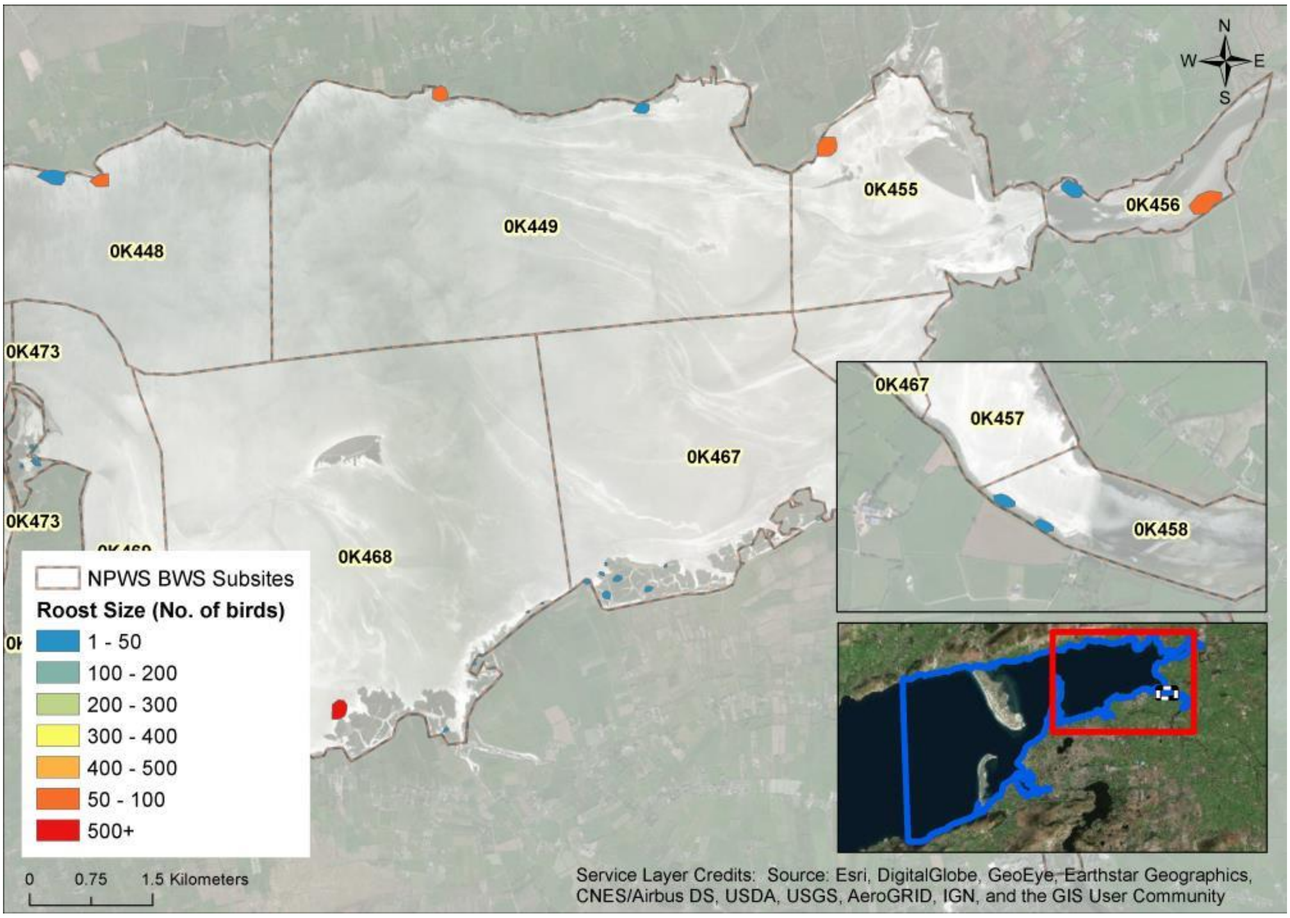


Figure 4.5: High tide roost sites: Laughtalla to Inch



5 Intertidal aquaculture in Castlemaine Harbour

5.1 Scope of activity

Shellfish culture in Castlemaine Harbour Special Protection Area (SPA) currently consists of 31 licenced sites for intensive oyster culture, one licenced site for extensive oyster culture and 16 licenced sites for mussel culture. At present there are also 34 pending licence applications for extensive oyster culture, one pending licence decision for a combined extensive mussel rope culture and bottom mussel cultivation site and two pending licence variations (i.e. from mussel culture to intensive oyster culture). In addition to the existing and pending licences there are 13 licence applications for new areas of intensive oyster culture and two new licence applications for extensive mussel culture.

Each new and pending licence application, if consented, will last for 10 years. The spatial extent of the licenced, pending and new application sites are shown in Figure 5.1. Many sites are accessed by small boats launched from Cromane whilst other sites are accessed over land. Land access routes are shown in Figure 5.2.

Figure 5.1: Shellfish culture licence sites

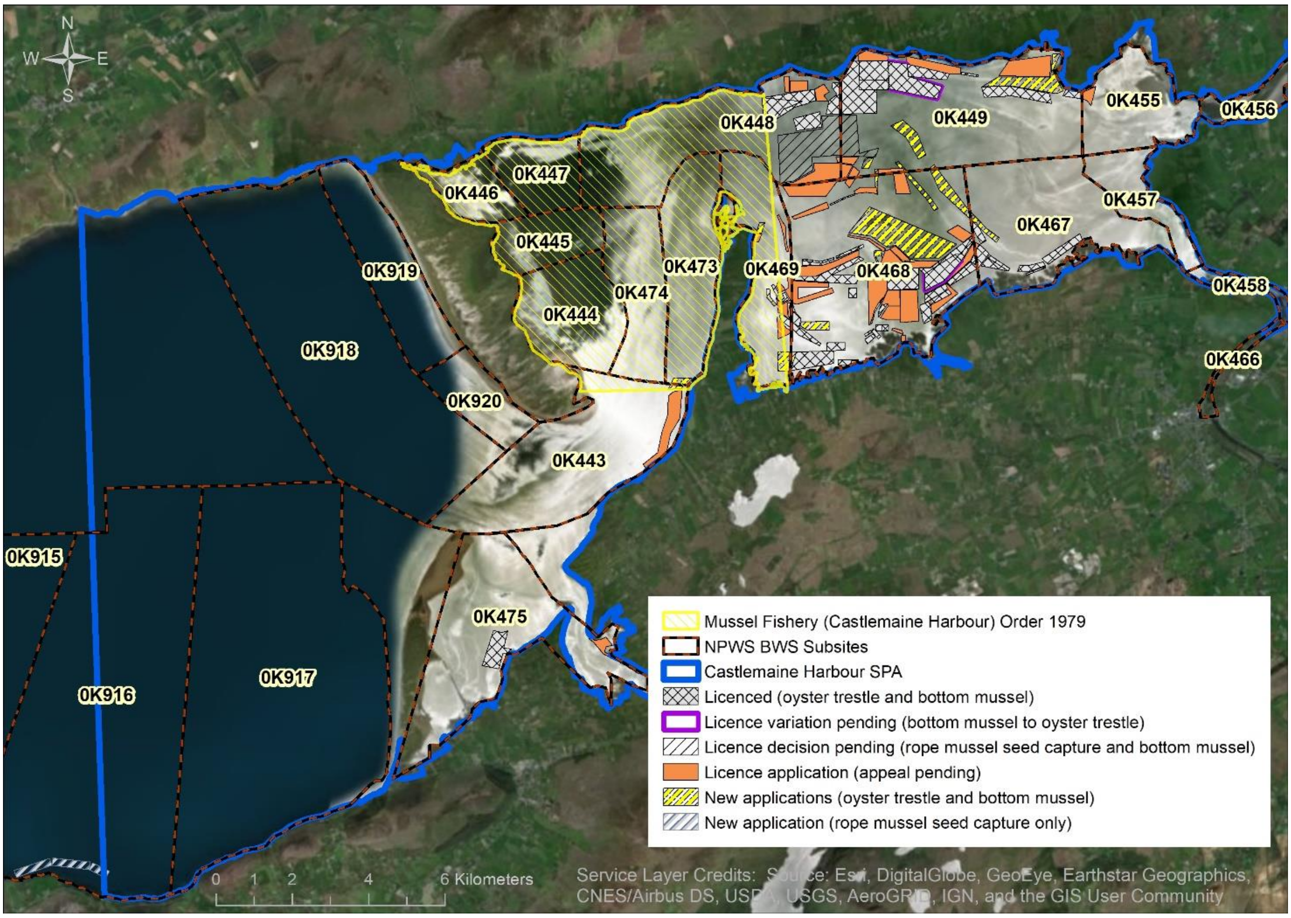
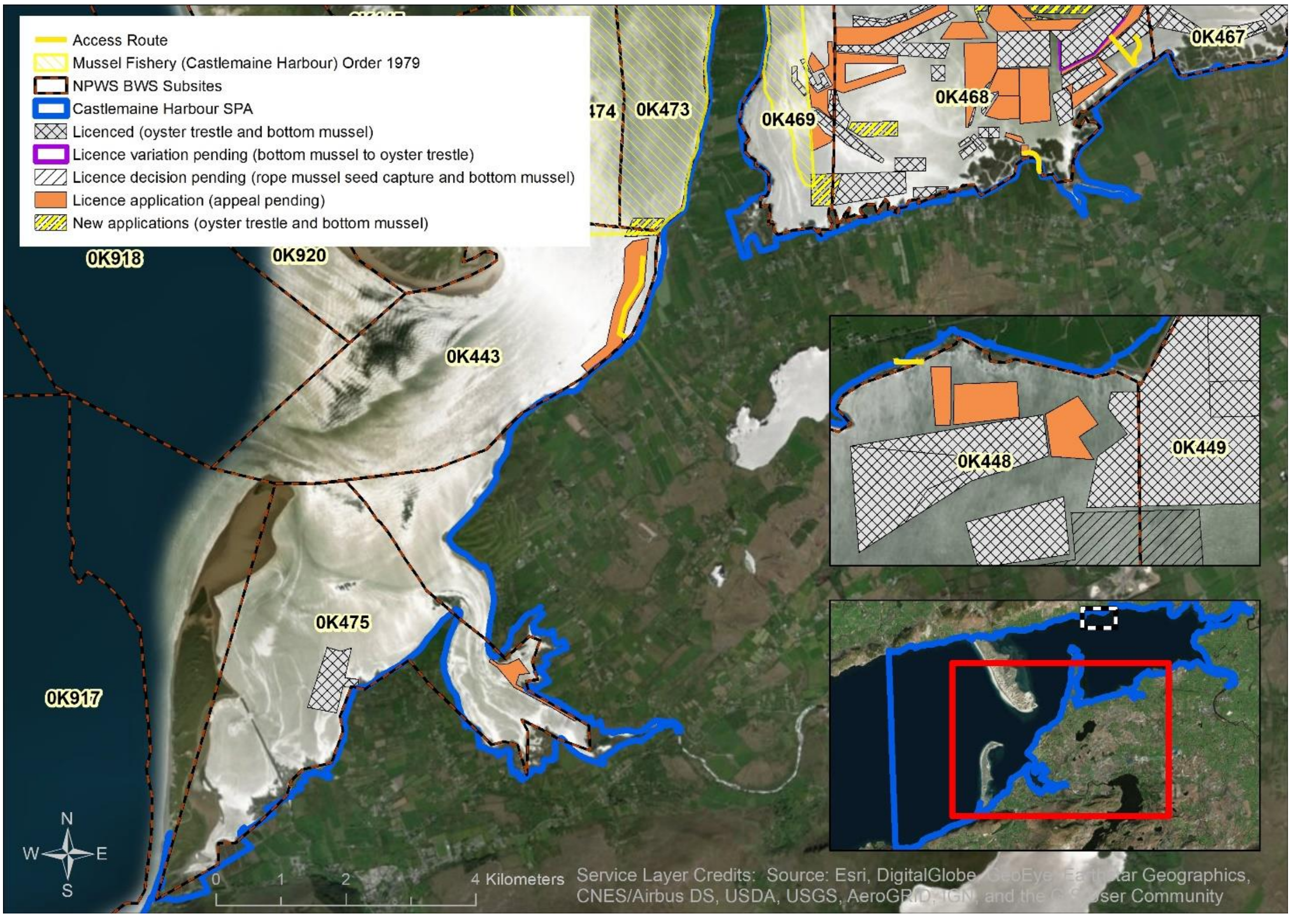


Figure 5.2: Land access routes



5.2 Description of activity

5.2.1 Oyster culture

Two types of oyster culture are practiced, intensive (bags suspended in the intertidal zone by trestles) and extensive (grown on intertidal sediment). Activities related to the cultivation of oysters include:

- Annual introduction of seed or ‘spat’ oysters purchased from hatcheries in France and the UK (typically April–June, sometimes March and October–November);
- Grading, thinning and growing out in spring, two to three times over a 2.5 year growing period; and
- Harvesting (typically November–January but can occur at any time) (Marine Institute, 2011, p. 11–12).

Oyster sites “are generally accessed on every tide [2-3 hours either side of low tide] (once per fortnight) for checking but bag turning takes place on the extreme low tides between March and November averaging 6 times per/ year at each site. The majority of oyster growers access the sites by boat from Cromane point where storage of equipment and grading of oysters also occur” (Marine Institute, 2011 p. 12).

5.2.2 Mussel rope culture

There is one pending licence decision site and one new application site for intensive subtidal rope mussel on-growing culture. This culture technique involves the use of 28, c. 100 m long double header ropes with floatation barrels (Figure 5.3). The ropes are spaced 50 m apart and are arranged approximately parallel to the water flow in seven groups of four ropes. The ropes are typically suspended in the water column 0.5 m above the sediment at low tide (Marine Institute, 2013) and tied to a 1.5 tonne mooring block by a 70 m long anchor rope (Butler, 2018). These ropes will be deployed by boat in March or April for the capture of seed mussel with stripping and bringing ashore occurring between September and November (Marine Institute, 2013; Butler, 2018; O'Beirn, 2018).

Figure 5.3: Mussel rope (Butler, 2018)

5.2.3 Bottom mussel culture

Two types of bottom mussel culture are practiced, intensive (high mussel density) and extensive (low mussel density). The adopted 'Fisheries Natura Plan for mussel seed (*Mytilus edulis*) in Castlemaine Harbour, 2016–2023' describes the following activities:

- Subtidal seed mussel fishing by means of boat-based dredging within Castlemaine Harbour (spring and autumn, subject to seed availability);
- Supplementary sourcing of seed mussel from beyond Dingle Bay;
- Subtidal relying and on-growing in the mussel fishery order area and on licensed aquaculture sites in the inner harbour;
- Intertidal relaying of seed mussel in nursery areas for subsequent transfer (typically June–August) and subtidal on-growing;
- Harvesting (from late September until mid-March); and
- Predator control (green crab *Carcinus maenas*).

The impacts related to the seed fishery activities between 2016 and 2026, i.e. the extraction of seed mussel and the subsequent intertidal and subtidal relay have been assessed by the Marine Institute (Marine Institute, 2016, p. 62–96). No adverse effect on the integrity of the site was determined alone or in combination with other activities, plans or projects. On this basis, seed fishery activities alone are not assessed further in this assessment and any reference to the impacts of the seed fishery activities will be in respect of in combination impacts only.

6 Potential impacts of intertidal aquaculture

The potential impact of aquaculture activities on Castlemaine Harbour SPA previously assessed by the Marine Institute (2011, p. 24; 2016, p. 87–89) include the following:

Changes in invertebrate communities found in inter-tidal and sub-tidal habitats
- Habitat smothering;
- Changes in turbidity/ sediments;
- Changes in oxygen levels;
- Introduction of non-native species;
- Abrasion/Physical disturbance/Compaction;
- Displacement or relocation of prey species;
- Selective extraction of target species; and
- Selective extraction of non-target species.

Spatial proximity of special conservation interest features
- Noise/visual disturbance; and
- Displacement.

6.1 Changes in invertebrate communities found in intertidal and subtidal habitats

It has been widely recorded that aquaculture structures and activities can result in changes within intertidal and subtidal invertebrate communities (e.g. Pearson & Rosenberg, 1978; Murray *et al*., 2007; Dumbauld *et al*., 2009). The impacts on benthic habitats are likely to be greatest directly beneath cultivation structures and confined to an area within 50m of a bivalve culture (Chamberlain *et al*. 2001; Beadman *et al*. 2004; Ysebaert *et al*., 2009).

The overall impact direction and magnitude is however likely to be determined by site specific conditions such as sediment type, water depth and flushing rate are known to influence (Chamberlain *et al*. 2001; Newell 2004; Dumbauld *et al*., 2009). The relationship between aquaculture intensity at a site and the benthic environment is current not well known (McKindsey *et al*., 2011) although effects at the estuary scale could occur as the fraction of cultured area rises, especially in poorly flushed sites (Dumbauld *et al*., 2009). Where impacts do occur, soft-sediment communities recovery faster (weeks or months) (Dolmer *et al*., 1998; Forrest *et al*., 2009 and references therein) than for example eel grass *Zostera marina* (several years) (Cunha *et al*., 2004).

Indirect effects on waterbird as a result of changes in the benthic invertebrate communities include changes in distribution and abundance are likely to occur (Cadlow *et al*., 2003; Christianen *et al*., 2015; Kelly *et al*., 1996; Hilgerloh *et al*. 2001; Gittings & O'Donoghue 2012) but are typically species and site specific (Callier *et al*., 2017).

Treated wastewater discharges directly into Castlemaine Harbour at one location and indirectly from a further 20 locations within 20km (Marine Institute, 2011, p. 54). Where organic enrichment of sediments occurs, infaunal diversity is likely to reduce but common opportunistic species may be observed (Keeley, 2013). This superabundance can change the food resources for waterbirds at a within-site spatial scale leading to site-specific and species-specific effects (Pringle & Burton, 2017). The influence of tidal flushing in coastal waters however, means that such sites are typically less sensitive to nutrient loading (Pringle & Burton, 2017). As a result, in combination impacts related to wastewater discharges are not considered further in this report.

6.1.1 Habitat smothering

Habitat smothering can occur, over a moderate to long term (Keeley, 2013), as a result of:

- The physical footprint of bottom mussel cultures (Asmus, 1987; Murray *et al*., 2007; Ysebaert *et al*., 2008; McKindsey *et al*., 2011);
- The installation of cultivation structures such as trestles, bags, anchors and ropes, especially where they are aligned perpendicular to tidal currents, leading to altered hydrodynamic conditions and changes in seabed topography (Kirby, 1994; Cayocca *et al*., 2008); and
- Increased sediment deposition (faeces and pseudofaeces) directly beneath the cultures, especially where cultivation structures are in high density (Keeley, 2013).

Whilst habitat smothering will occur under shellfish cultures, the Marine Institute (2011, p. 34; p. 45) have previously determined that the water movement within Castlemaine Harbour is high and would reduce the risk of accumulations of organic matter. The estuary-wide scale at which water movement operates means that, alone or cumulatively, the effects of habitat smothering from shellfish culture on waterbirds is not likely to be appreciable. Furthermore, 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.

No other activities, plans or projects have been identified that may act in combination with the licence applications with respect to habitat smothering.

The assessment of overall impact and the identification of links to SCIs are summarised below in Table 6.1 and 6.2 respectively.

Summary Description	Severity	Likelihood	Impact Score
Localised deposition of faeces and pseudofaeces over existing sediment layers. Can result in a change to the biological composition and/or availability of prey items particularly where intensive shellfish culture occurs. High water flows in Castlemaine Harbour is likely to minimise the potential impact.	1 (Low)	1 (Low)	1 (Low)

Table 6.1: Impact summary: habitat smothering

SCI	Link Score	Justification
Light-bellied Brent Goose	1	May be considered to have a localised, indirect impact of medium to long term duration with no appreciable effect because of the high water movement within Castlemaine Harbour.
Wigeon	1	
Pintail	1	
Ringed Plover	1	
Bar-tailed Godwit	1	
Sanderling	1	
Mallard	1	
Oystercatcher	1	
Turnstone	1	

Greenshank	1	
Redshank	1	
Common Scoter	0	No material overlap with foraging range.
Red-throated Diver	0	
Scaup	0	
Cormorant	0	

Table 6.2: Impact link score: habitat smothering

6.1.2 Changes in turbidity/sediments

Compared to baseline conditions, site specific changes in water turbidity may occur following the resuspension of biodeposits (Keeley, 2013) or where erosion around cultivation structures occurs (see review by Forrest *et al*., 2009). Baseline levels of turbidity could however be reduced by bivalve filter feeding (see review by Gallardi, 2014). Whichever effect may occur in Castlemaine Harbour, it is likely to be negligible compared to the scale of change in sediment transport patterns driving the increased sedimentation and storm surges following the 2008 breach of the Rossbeigh barrier dune system (O'Shea & Murphy, 2016).

As part of bivalve filter feeding processes, large faecal pellets (500-3000 µm) rapidly settle below the culture (Cranford *et al*., 2003). The impact of this biodeposition on the benthic invertebrate communities will vary according to water depth and prevailing currents (see review by Gallardi, 2014). Where bottom cultured bivalves are located, sediment trapping as well as biodeposition can lead to high sedimentation rates (Ysebaert *et al*., 2009). In general, sediments in culture locations are likely to have a smaller grain size with higher particulate organic carbon, nitrogen and phosphorus (Ragnarsson and Raffaelli 1999, Chamberlain et al. 2001, Smith and Shackley 2004).

The deposition of shells on soft-sediment areas as a result of natural mortality or harvesting activities can result in fundamental long-term shifts in benthic community composition (Keeley, 2013). These deposits in soft sediments can increase diversity, biomass and abundance of infauna and epifauna (Gallardi, 2014). The persistence of such effects varies from short (small shells and sticks) to long term (e.g. large shells, rope and plastics) and is dependent on the rate of breakdown in the environment (Keeley, 2013).

The density of cultured mussels has been shown in some studies not to adversely impact on bird abundance (Cadlow *et al*., 2003) and increased organic loading by intertidal mussel culture has resulted in the increased abundance of some bird species (Christianen *et al*., 2015).

Changes in turbidity and sediments are likely to arise in Castlemaine Harbour as a result of (Marine Institute, 2011):

- The placement of mussel seed;
- The dredging of mussels;
- Baffling effects of structures on shore;
- The placement of mussel seed;
- Increased organic loading on seabed; and
- Beneath the cultivation of Pacific oyster and rope grown mussels.

No appreciable effects, alone or cumulatively, are considered likely because the magnitude of the natural sediment (Marine Institute, 2011, p.34) and hydrological dynamics of Castlemaine Harbour (Marine Institute, p.45) much large scale than the potential impact. Furthermore, if the impact does occur it will likely be localised and reversible in the medium term to long term (Keeley, 2013) with the potentially neutral or beneficial effects for foraging waterbirds in the meantime. The severity of any changes in turbidity and sediment on waterbirds are therefore likely to be low (Marine Institute, 2011, p.34).

No other activities, plans or projects have been identified that may act in combination with the licence applications with respect to habitat smothering.

The assessment of overall impact and the identification of links to SCIs are summarised below in Table 6.3 and 6.4 respectively.

Summary Description	Severity	Likelihood	Impact Score
Localised increase in water turbidity and sediment build up. Can result in a change to the biological composition and/or availability of prey items particularly where intensive shellfish culture occurs. Potential impact is not likely to be appreciable against the magnitude of the natural sediment and hydrological dynamics in Castlemaine Harbour.	1 (Low)	1 (Low)	1 (Low)

6.3

SCI	Link Score	Justification
Light-bellied Brent Goose	1	May be considered to have a localised, indirect impact of medium to long term duration with no appreciable effect because of the highly dynamic water and sediment regime within Castlemaine Harbour.
Wigeon	1	
Pintail	1	
Ringed Plover	1	
Bar-tailed Godwit	1	
Sanderling	1	
Mallard	1	
Oystercatcher	1	
Turnstone	1	
Greenshank	1	
Redshank	1	
Common Scoter	0	No material overlap with foraging range.
Red-throated Diver	0	
Scaup	0	
Cormorant	0	

Table 6.4: Impact link score: changes in turbidity/sediments

6.1.3 Changes in oxygen levels

The decomposition of high levels of organic deposits (faeces and pseudofaeces) produced by bivalve cultures can increase oxygen demand in the benthic environment resulting in the prevalence of anaerobic conditions (see review by Gallardi, 2014). These anaerobic conditions result in changes in sediment chemistry and consequently benthic invertebrate communities shift from assemblages dominated by suspension feeders towards those dominated by hydrogen sulphide-tolerant species, smaller-bodied opportunistic deposit feeders, scavengers and carnivores (see review by Gallardi, 2004).

In high energy, well flushed systems the impacts of deposition may be less compared to those of shallow, poorly flushed sites or low energy sub-tidal locations (Keeley, 2013; see review by Gallardi, 2014). Where sites predominantly comprise of coarse sandy sediments, recovery appears to be relatively rapid (months) once farming ceases (Keeley, 2013).

As described above, no appreciable effects, alone or cumulatively, are considered likely because the magnitude of the natural sediment (Marine Institute, 2011, p.34) and hydrological dynamics of Castlemaine Harbour (Marine Institute, p.45) much large scale than the potential impact. Therefore the severity of the impact in respect of indirect impacts on waterbirds is likely to be low.

No other activities, plans or projects have been identified that may act in combination with the licence applications with respect to changes in oxygen levels.

The assessment of overall impact and the identification of links to SCIs are summarised below in Table 6.5 and 6.6 respectively.

Summary Description	Severity	Likelihood	Impact Score
Decomposition of high levels of organic deposits (faeces and pseudofaeces) produced by shellfish cultures can result in oxygen depletion in sediment layers. A change to the biological composition and/or availability of prey items can occur particularly where intensive shellfish culture occurs. Potential impact is not likely to be appreciable against the magnitude of the natural sediment and hydrological dynamics in Castlemaine Harbour.	1 (Low)	1 (Low)	1 (Low)

Table 6.5: Impact summary: changes in oxygen levels

SCI	Link Score	Justification
Light-bellied Brent Goose	1	May be considered to have an indirect impact of medium to long term duration with no appreciable effect because of the highly dynamic water and sediment regime within Castlemaine Harbour.
Wigeon	1	
Pintail	1	
Ringed Plover	1	
Bar-tailed Godwit	1	
Sanderling	1	
Mallard	1	
Oystercatcher	1	
Turnstone	1	
Greenshank	1	
Redshank	1	
Common Scoter	0	No material overlap with foraging range.
Red-throated Diver	0	
Scaup	0	
Cormorant	0	

Table 6.6: Impact link score: changes in oxygen levels

6.1.4 Introduction of non-native species

In Europe the introduction of non-native species in aquaculture is controlled by 'Council Regulation (EC) No 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture'. Pacific oyster can significantly alter diversity, community structure and ecosystem processes (Herbert *et al*., 2016). Experimental comparison of the effects of native blue mussel and non-native Pacific oyster on benthic invertebrate communities has shown differences in the abundances of component species (Kochmann *et al*., 2008).

Similarly the impacts of non-native bivalves on waterbirds is also largely unknown (Waser *et al*., 2016). Research on the effects of Pacific oyster in the Wadden Sea identified adverse effect only on wading birds that preferentially foraged on native blue mussel, i.e. oystercatcher, dunlin and knot (Waser *et al*., 2016). The resilience of blue mussel to the presence of Pacific oyster is considered to be very low (Mainwaring *et al*., 2014) and that mussel beds in the presence of adjacent farmed Pacific oyster are likely to be quickly replaced by oyster beds (Kochmann *et al*., 2008).

The likelihood of an impact from the cultivation of Pacific oyster at Castlemaine Harbour (Marine Institute, 2011, p. 24) is unlikely because triploid stock is widely used. Triploid Pacific oysters are relatively, though not completely sterile (Gong *et al*., 2004), and therefore the establishment in the wider environment is unlikely. No significant spawning has been observed, there are no accumulations of naturally spawned Pacific oyster in the area and the extensive use of triploid oyster reduces the risk of spawning (Marine Institute, 2011, p. 46). In general, there is likely to be no appreciable effect, alone or cumulatively, on waterbirds and the severity of the indirect impact is likely to be low.

No other activities, plans or projects are known that may act in combination with the licence applications with respect to introduction of non-native species.

The assessment of overall impact and the identification of links to SCIs are summarised below in Table 6.7 and 6.8 respectively.

Summary Description	Severity	Likelihood	Impact Score
Introduction of Pacific oyster can result in the loss of native blue mussel. Potential impact is not likely given the use of triploid (reproductively near-sterile) stock.	2 (Medium)	1 (Low)	1 (Low)

Table 6.7: Impact summary: introduction of non-native species

SCI	Link Score	Justification
Oystercatcher	1	Whilst an impact pathway exists by virtue of an indirect impact resulting from the potential loss of blue mussel, the use of triploid Pacific oyster minimises the likelihood of establishment in the wider environment.
Light-bellied Brent Goose	0	No evidence of an impact pathway.
Wigeon	0	
Pintail	0	
Ringed Plover	0	

Bar-tailed Godwit	0	
Sanderling	0	
Mallard	0	
Turnstone	0	
Greenshank	0	
Redshank	0	
Common Scoter	0	
Red-throated Diver	0	
Scaup	0	
Cormorant	0	

Table 6.8: Impact link score: introduction of non-native species

6.1.5 Abrasion/Physical disturbance/Compaction

Changes in benthic invertebrate communities can arise from the physical external influence on the sediment layers. Activities such as mussel harvesting by bottom dredging, vehicle use, propeller wash and personnel walking to, from and between cultivation structures can result in changes in sediment structure and characteristics (De Grave *et al*., 1998; see review by Gillardi, 2004). Access routes used in intertidal areas, presumably by virtue of persistent compaction of the sedimentary habitats by vehicles, are considered disturbing (De Grave *et al*., 1998; Forde *et al*., 2015). These activities are likely to be localised to access routes the cultivation sites and will typically impact surface dwelling and fragile shallow burrowing species; including *Hydrobia*, an important prey species for many waterbird species (De Grave *et al*., 1998; Masero *et al*., 2008).

As with the impact of changes in sediments, the abrasion/physical disturbance/compaction in Castlemaine Harbour is likely to be localised and occur as a result of the dredging of mussels, use of vehicles and foot traffic on shore (Marine Institute, 2011, p. 24). The severity of the impact of likely to be low. The exception to this would be where habitat impacts coincides with the distribution of eel grass, a habitat with a longer recovery time than soft sediments. For waterbird species that preferential forage on eel grass, i.e. light-bellied brent goose and wigeon, the severity is considered to be moderate. It should be noted however that no licence application sites are located on eel grass beds.

No other activities, plans or projects are known that may act in combination with the licence applications with respect to abrasion/physical disturbance/compaction.

The assessment of overall impact and the identification of links to SCIs are summarised below in Table 6.9 and 6.10 respectively.

Summary Description	Severity	Likelihood	Impact Score
Dredging of mussels, use of vehicles and foot traffic on shore and result in changes in sediment structure and characteristics. As a result a measurable change to the biological composition and/or availability of prey items can occur.	1 (Low)	2 (Medium)	1 (Low)

Potential impact is not likely to be appreciable because of its localised extent.			

Table 6.9: Impact summary: abrasion/physical disturbance/compaction

SCI	Link Score	Justification
Light-bellied Brent Goose	1	A localised indirect impact of short to medium term duration with no appreciable effect because of the highly dynamic water and sediment regime within Castlemaine Harbour.
Wigeon	1	
Pintail	1	
Ringed Plover	1	
Bar-tailed Godwit	1	
Sanderling	1	
Mallard	1	
Oystercatcher	1	
Turnstone	1	
Greenshank	1	
Redshank	1	
Common Scoter	0	No impact pathway identified.
Red-throated Diver	0	
Scaup	0	
Cormorant	0	

Table 6.10: Impact link score: abrasion/physical disturbance/compaction

6.1.6 Displacement or relocation of prey species

The dredging of mussels is likely to result in the displacement or relocation of waterbird species (Marine Institute, 2011, p.24). Dredging may result in a temporary increase in species outside the dredged area, for example polychaete worms (Dolmer *et al*., 2001), which declines over time; probably as a result of predation (DeGrave *et al*., 1998). The relocation of seed mussel on soft sediments will result in habitat smothering, changes in turbidity/sediments and oxygen levels as discussed above.

Displacement and relocation of prey species is likely to occur although there is likely to be no appreciable effect because of the likely short term effects (Dolmer *et al*., 2001; Keeley *et al*., 2013). The severity of the impact in intertidal soft sediment areas is likely to be low.

No other activities, plans or projects are known that may act in combination with the licence applications with respect to displacement or relocation of prey species.

The assessment of overall impact and the identification of links to SCIs are summarised below in Table 6.11 and 6.12 respectively.

Summary Description	Severity	Likelihood	Impact Score
The dredging of mussels will result in the displacement or relocation of prey species potentially making prey more available for a period of time. Potential impact is not likely to be appreciable because of the high recoverability of soft sediment in the short term.	1 (Low)	1 (Low)	1 (Low)

Table 6.11: Impact summary: displacement or relocation of prey species

SCI	Link Score	Justification
Light-bellied Brent Goose	1	May be considered to have an indirect impact of short term duration which may be positive.
Wigeon	1	
Pintail	1	
Ringed Plover	1	
Bar-tailed Godwit	1	
Sanderling	1	
Mallard	1	
Oystercatcher	1	
Turnstone	1	
Greenshank	1	
Redshank	1	
Common Scoter	0	No impact pathway identified.
Red-throated Diver	0	
Scaup	0	
Cormorant	0	

Table 6.12: Impact link score: displacement or relocation of prey species

6.1.7 Selective extraction of target species

The removal of target species as part of the allowable catch, will occur (Marine Institute, 2011, p. 24). This impact is most likely to affect species that preferentially feed on blue mussel, i.e. oystercatcher. The removal of mussels and the exposure of the soft sediments below is also likely to result in a reduction in the species diversity, biomass and abundance of infauna and epifauna that benefited from the increased habitat heterogeneity of the mussel bed matrix (Marine Institute, 2011, p.39).

Modelling undertaken by Bowgen *et al*., (2015) indicates that oystercatcher populations are most affected by the removal of the largest and most profitable prey at the point at which only the smallest size prey were available. It should be noted that, subject to the absence of bird control measures, some beneficial effect may occur in combination with the seed mussel fishery when seed mussel is moved from subtidal areas or low in the tidal frame to more accessible locations higher in the tidal frame.

Oystercatcher have been known to forage on Pacific oyster in Europe (Scheiffarth *et al*., 2007) and for those individuals in the population that are proficient in opening oysters only those oyster with a shell length up to 16 cm may be accessible (Butler, 1979). No other European waterbird species are known to forage on oyster species.

The impacts of selective extraction of target species is only likely to affect waterbirds in respect of the extraction of bottom cultured blue mussel. The severity is likely to be low for all species. For oystercatcher there is a stronger indirect impact pathway because of the species preference for foraging on blue mussel.

No other activities, plans or projects are known that may act in combination with the licence applications with respect to selective extraction of target species.

The assessment of overall impact and the identification of links to SCIs are summarised below in Table 6.13 and 6.14 respectively.

Summary Description	Severity	Likelihood	Impact Score
Dredging of mussels resulting in the selective extraction of target species causing a change in the availability of prey (i.e. mussles). Potential impact potentially reversed by seed mussel being moved from subtidal areas or low in the tidal frame to more accessible locations higher in the tidal frame.	1 (Low)	1 (Low)	1 (Low)

Table 6.13: Impact summary: selective extraction of target species

SCI	Link Score	Justification
Oystercatcher	2	Likely to have an indirect impact of medium to long term duration with minor effects because of the additional availability of prey when seed mussel is moved from subtidal areas or low in the tidal frame to more accessible locations higher in the tidal frame.
Light-bellied Brent Goose	0	No impact pathway identified.
Wigeon	0	
Pintail	0	
Ringed Plover	0	
Bar-tailed Godwit	0	
Sanderling	0	

Mallard	0	
Turnstone	0	
Greenshank	0	
Redshank	0	
Common Scoter	0	
Red-throated Diver	0	
Scaup	0	
Cormorant	0	

Table 6.14: Impact link score: selective extraction of target species

6.1.8 Selective extraction of non-target species

Non-target species in Castlemaine Harbour are removed by the dredging of mussels and the potting of crabs (Marine Institute, 2011, p.24).

Mussel beds create a complex habitat for surface dwelling and hard substrate species including predators. The dredging of mussel seed beds not only removes the target mussels but also removes the species assemblages associated with the mussel matrix (Marine Institute, 2011, p.39).

The presence of cultivated shellfish can increase the abundance of predators such as crabs, fish, gastropods and echinoderms (see review by Callier *et al*., 2017). At Castlemaine Harbour a predator control programme associated with the sub-tidal aquaculture plots removes approximately 300 tonnes of green crab every year (Marine Institute, 2011, p. 14). In addition to this an unknown quantity of cockle *Cerastoderma edule* and periwinkle *Littorina littorea* are commercially harvested (Marine Institute, 2011, p14; p.126).

The impacts of selective extraction of non-target species are likely to occur from crab predator control and in respect of intertidal dredging of mussels. The severity of predator control is likely to be low because green crab is not a significant food resource for any of the species of conservation interest except red-throated diver (Marine Institute, 2011; p. 125). Red-throated diver however forage in parts of the SPA more distant from the shellfish culture areas, i.e. in subsites 0K473, 0K474, 0K915, 0K917 and 0K918 (Figure 2.3). The importance of the periwinkle resource within Castlemaine Harbour is unknown and the cockle resource is not considered to be important for any of the also species of conservation interest (Marine Institute, 2011; p.126). On this basis the severity of harvesting of non-target species is considered to be low. The severity of the dredging of mussels in intertidal soft sediment is likely to be low because of the likely short term effects (Dolmer *et al*., 2001; Keeley, 2013).

No other activities, plans or projects are known that may act in combination with the licence applications with respect to selective extraction of non-target species.

The assessment of overall impact and the identification of links to SCIs are summarised below in Table 6.15 and 6.16 respectively.

Summary Description	Severity	Likelihood	Impact Score
Dredging of mussels, harvesting of other molluscs and predator control resulting in	1 (Low)	1 (Low)	1 (Low)

the selective extraction of non-target species causing a change in the availability of prey. Potential impact not likely to be appreciable.			

Table 6.15: Impact summary: selective extraction of non-target species

SCI	Link Score	Justification
Light-bellied Brent Goose	1	May be considered to have an indirect impact of short to long term duration with minor effects because of the high recoverability of soft sediment communities and because none of the non-target species are significant prey species for the SCIs where foraging range significantly overlaps with shellfish culture activities.
Wigeon	1	
Pintail	1	
Red-throated Diver	1	
Ringed Plover	1	
Bar-tailed Godwit	1	
Sanderling	1	
Mallard	1	
Oystercatcher	1	
Turnstone	1	
Greenshank	1	
Redshank	1	
Common Scoter	0	No material overlap with foraging range.
Scaup	0	
Cormorant	0	

Table 6.16: Impact link score: selective extraction of non-target species

6.2 Spatial proximity of special conservation interest features

Disturbance from noise and the visual presence of vessels, vehicles and people has been found to have a fundamental influence on the waterbird behaviour (e.g. Fitzpatrick & Bouchez, 1998; Goss-Custard & Verboven 1993; Riddington *et al*., 1996). The behavioural responsiveness of a bird is positively related to the bird's body condition such that birds in poor body condition are less likely to fly away or fly less distance from a source of disturbance compared to birds with comparatively better body condition (Beale & Monaghan, 2004). Such flight behaviour may also indicate the presence of alternative foraging habitat away from the source of disturbance (Gill *et al*., 2001).

The direct displacement of waterbirds as a result of the presence of aquaculture infrastructure is known to result in the displacement of species from intertidal foraging habitat (Gittings & O'Donoghue, 2012; 2014; 2017). In general, all waders that feed in small flocks or as widely dispersed individuals/loose flocks show a neutral or positive response to the presence of trestles whereas species that feed in large flocks of tightly packed individuals show a negative response (Gittings & O'Donoghue, 2012). Furthermore, it was found that the selection of mixed sediment or rocky shore sites for intertidal oyster culture would generally minimise the potential impact on waterbirds in respect of displacement (Gittings & O'Donoghue, 2012).

6.2.1 Noise /visual disturbance

All activities associated with aquaculture have been defined as having a moderate level of impact with the exact nature of disturbance being related to the number of people, type of boat used (motorised/nonmotorised), frequency of visits during a low-tide period, type and length of activity undertaken (NPWS, 2011a). Previous research at Castlemaine Harbour reported that 13 of 14 recorded disturbance events from all sources resulted a flight response (Gittings, 2010) which may indicate that alternative foraging areas are available. Disturbance may also occur at periods of high tide where access routes (Figure 4.2–Figure 4.5) and landing/sorting locations are in close proximity to high tide roosts.

The impact of disturbance is likely to occur at licence application sites where mussel and oyster aquaculture activities are proposed (Marine Institute, 2011; p.24). The zones within which the effects of disturbance can be measured have been calculated to cover large areas, however the effects vary between species and the time of year. The biological consequences of disturbance are difficult to quantify but the severity of disturbance activities from aquaculture activities are likely to be no lower than moderate (NPWS, 2011a; see also Cutts *et al*., 2009 in relation to disturbance from boats); high severity cannot be discounted resulting from the presence of people and vehicles on mud/sandflat (Cutts *et al*., 2013).

Recreational activities are known to result in the disturbance of special conservation interests and these activities may act in combination with the licence applications with respect to noise/visual disturbance.

Recreational disturbance is the only other activity, plan or project that may act in combination with the licence applications with respect to changes in noise/visual disturbance.

The assessment of overall impact and the identification of links to SCIs are summarised below in Table 6.17 and 6.18 respectively.

Summary Description	Severity	Likelihood	Impact Score
Disturbance events such as the use of vessels, the use of vehicles on shore and foot traffic on shore are known to displace birds from foraging habitat. Over time this can lead to adverse changes in the abundance and distribution of waterbird species. Potential impact is likely to be significant for foraging intertidal waterbirds sensitive to disturbance.	3 (high)	3 (High)	3 (High)

Table 6.17: Impact summary: noise/visual disturbance

SCI	Link Score	Justification
Light-bellied Brent Goose	3	Considered to have a direct impact of long term duration with a significant effect because of the known sensitivity of waterbirds to disturbance and the overlap of licence applications with important foraging areas.
Wigeon	3	
Pintail	3	

Ringed Plover	3	
Bar-tailed Godwit	3	
Sanderling	3	
Mallard	3	
Cormorant	3	
Oystercatcher	3	
Turnstone	3	
Greenshank	3	
Redshank	3	
Common Scoter	0	No material overlap with foraging range.
Red-throated Diver	0	
Scaup	0	

Table 6.18: Impact link score: noise/visual disturbance

6.2.2 Displacement

The significance of displacement appears to be site and species specific but as a result of limitations in the assessment there is often a high level of uncertainty. For example, Gittings & O'Donoghue (2017) found on one site that bar-tailed godwit showed a strongly negative response to the presence of trestles, although complete exclusion did not occur. Elsewhere bar-tailed godwit was found to be displacement by the presence of trestles but that this displacement was not significant (Gittings & O'Donoghue, 2014). For other species, i.e. light-bellied brent goose, curlew and redshank, it could not be concluded that there was even partially displacement from the trestles, particularly for light-bellied brent goose and redshank which have shown neutral or positive responses to the presence of trestles at other sites (Gittings & O'Donoghue, 2017).

Displacement and relocation of waterbirds is likely to occur, although the uncertainty of the impact direction and magnitude is high. Applying the precautionary principle, the severity of the impact is high for all intertidal foraging species (Table 6.19). For those species with a neutral or positive response, the impact pathway is considered to be minimal.

No other activities, plans or projects are known that may act in combination with the licence applications with respect to displacement.

SCI	Response*	Site fidelity**
Selection species		
Light-bellied Brent Goose	Variable	High
Wigeon	Unknown (negative)	Weak
Pintail	Unknown (negative)	Weak

Ringed Plover	Negative	High
Bar-tailed Godwit	Negative	Moderate
Sanderling	Negative	High
Additional Species of conservation interest		
Mallard	Unknown (negative)	Moderate
Oystercatcher	Neutral/positive	High
Turnstone	Neutral/positive	High
Greenshank	Neutral/positive	High
Redshank	Neutral/positive	Moderate
* Gittings & O'Donoghue, 2012, **NPWS, 2011a.		

Table 6.19: Displacement response of waterbird species to intertidal oyster cultivation

Recreational disturbance is the only other activity, plan or project that may act in combination with the licence applications with respect to displacement.

The assessment of overall impact and the identification of links to SCIs are summarised below in Table 6.20 and 6.21 respectively.

Summary Description	Severity	Likelihood	Impact Score
The presence of oyster trestles on intertidal foraging habitat is known to adversely change the abundance and distribution of some waterbird species. Potential impact is likely to be significant for foraging intertidal waterbirds sensitive to the presence of trestles.	3 (High)	3 (High)	3 (High)

Table 6.20: Impact summary: displacement

SCI	Link Score	Justification
Light-bellied Brent Goose	3	Considered to have a direct impact of long term duration with a significant effect because of the overlap with important foraging areas and known or potential negative response to the presence of oyster trestles.
Wigeon	3	
Pintail	3	
Ringed Plover	3	
Bar-tailed Godwit	3	
Sanderling	3	

Mallard	3	
Oystercatcher	1	Species known not to be sensitive to the presence of oyster trestles although some site specific negative response is possible.
Turnstone	1	
Greenshank	1	
Redshank	1	
Common Scoter	0	No material overlap with foraging range.
Red-throated Diver	0	
Scaup	0	
Cormorant	0	

Table 6.21: Impact link score: displacement

7 Assessment of likely significant effect

The vulnerability assessment was conducted using the methodology described in Section 2.9.1.2.

In consideration of the licence applications and licence variations alone and cumulatively, likely significant effects have been identified for (see also Table 7.1):

- Noise/visual disturbance for all intertidal SCIs and cormorant; and
- Displacement for all intertidal foraging SCIs except greenshank and redshank.

For all diving piscivore and molluscivore SCIs (common scoter, red-throated diver, scaup and cormorant) foraging is typically concentrated in the subtidal areas of the outer harbour (National Parks and Wildlife Service, 2011a). No likely significant effects are predicted because:

- There is no appreciable overlap of key foraging areas in the outer harbour (e.g. 0K918) with the new or pending licence application sites for subtidal mussel rope culture;
- The potential impacts of noise/visual disturbance arising from subtidal mussel rope culture when setting the ropes and when collecting seed mussel will be very infrequent, low intensity, localised and short-term in duration;
- The potential impacts of intertidal cultures will be localised and affect the benthic invertebrate communities of the intertidal zone only; and
- There are no in combination impacts between the new subtidal mussel rope culture site or the intertidal relay of bottom grown mussels outside the Mussel Fishery (Castlemaine Harbour) Order 1979 area with the activities of the subtidal mussel seed fishery; as assessed by the Marine Institute (2016).

Whilst taking into account the existing licenced sites as part of baseline conditions, the licence applications and licence variations are therefore likely to result in:

- A reduction of functional foraging habitat area;
- Disturbance to key species; and
- A reduction in species density.

The assessment of adverse effect on site integrity for the new licence applications and licence variations will consider the impacts on each licence site alone. Where no adverse effect can be concluded beyond reasonable scientific doubt (European Communities, 2002) for the licence site alone, the assessment of adverse effect on site integrity will consider the impacts of licence sites cumulatively with one another. Where no adverse effect on site integrity can be concluded alone or cumulatively the assessment will consider the impacts of licence application and licence variation sites impacts in combination with existing licenced shellfish culture sites and the baseline level of recreational disturbance operating within Castlemaine Harbour.

SCI	Habitat smothering	Changes in turbidity/ sediments	Changes in oxygen levels	Introduction of non-native species	Abrasion/Physical disturbance/Compaction	Displacement or relocation of prey species	Selective extraction of target species	Selective extraction of non-target species	Noise / visual disturbance	Displacement of SCI
Selection Species										
Light-bellied Brent Goose	6	6	6	0	6	6	0	0	54	54
Wigeon	2	2	2	0	4	2	0	0	18	18
Pintail	2	2	2	0	2	2	0	0	18	18
Common Scoter	0	0	0	0	0	0	0	0	0	0
Red-throated Diver	0	0	0	0	0	0	0	0	0	0
Ringed Plover	6	4	4	0	4	4	0	4	36	36
Bar-tailed Godwit	4	2	2	0	2	2	0	2	18	18
Sanderling	6	2	2	0	2	2	0	2	18	18
Additional Species of conservation interest										
Mallard	6	6	6	0	6	6	0	0	54	54
Scaup	0	0	0	0	0	0	0	0	0	0
Cormorant	0	0	0	0	0	0	0	0	0	0
Oystercatcher	2	2	2	2	2	2	4	2	18	6
Turnstone	3	3	3	0	3	3	0	3	27	9
Greenshank	4	4	4	0	4	4	0	4	36	12
Redshank	6	6	6	0	6	6	0	6	54	18

Table 7.1: Impact Risk Assessment

8 Stage 2 Appropriate Assessment

8.1 Impact prediction

8.1.1 Introduction

Long term displacement from foraging habitat is equivalent to habitat loss and can lead to declines in waterbird numbers (Wright *et al*., 2014). The impact of both displacement from oyster trestles and from disturbance will be the loss of functional habitat for the duration of the licences (10 years).

Habitat loss can occur as a result of an increased frequency of disturbance events over baseline conditions; and/or displacement through the introduction of aquaculture infrastructure. This habitat loss will be variable in duration, displacement from oyster trestles will occur for the duration of time the trestles are *in situ.* The effects of noise/visual disturbance stimuli are likely to occur during most suitable tides for husbandry (Gittings & O'Donoghue, 2012) and potentially for a short period of time, up to a week, thereafter (Cutts *et al*., 2009).

Chronic disturbance of foraging habitat can have significant consequences on the energy budget of individual waterbirds (Davidson & Rothwell, 1993). Patterns of site occupancy in waterbirds are driven by species-specific site fidelity (Table 6.19) within and between winters (Rehfisch *et al*. 1996, Burton 2000; Jackson *et al*. 2004). The consequences of disturbance are therefore potentially more adverse for species showing strong site fidelity compared to those species that more readily move to alternative foraging habitat areas (Wright *et al*., 2014).

It is uncertain if the presence of oyster trestles acts synergistically with noise/visual disturbance stimuli to create an impact of greater magnitude. Following Gittings & O'Donoghue (2012), as displacement from oyster trestle areas and disturbance result in habitat loss, impact predictions for both displacement and disturbance are assessed cumulatively.

Criteria defined previously applied to the appropriate assessment of shellfish culture in Castlemaine Harbour SPA (Marine Institute, 2016) were used to characterise the predicted impact. The criteria are:

1. **Criterion 1:** The impact is predicted to cause spatial displacement (S) of >25% of the total Castlemaine Harbour population of an SCI; or
2. **Criterion 2:** The impact is predicted to cause spatial displacement (S) of 5% or more of an SCI with a long term population trend (P) of less than -25%; or
3. **Criterion 3:** The impact is predicted to cause spatial displacement (S) of 5% or more of an SCI with a long term population trend (P) of less than -25%, but the cumulative value (S+P) is -25% or more.
4. **Criterion 4:** The impact is predicted to cause spatial displacement of less than 5% which is not likely to be detectable (Gittings & O'Donoghue, 2012).

A comparison of the long term national population trends of wigeon, ringed plover, oystercatcher and turnstone are suggestive of site specific drivers of change are operating at Castlemaine Harbour SPA (Table 8.1) and that these species are most vulnerable to changes in the impacts.

Species	National Trend 1994/95-2013/14 (%)	Castlemaine Harbour 2012/13–2016/17 (%)
Selection Species		
Light-bellied Brent Goose	+87.11	+74

Wigeon	-36.67	-57
Pintail	-5.05	+463
Ringed Plover	+16.65	-24
Bar-tailed Godwit	+38.57	+259
Sanderling	+90.40	+244
Additional Species of Conservation Interest		
Mallard	-15.06	-12
Oystercatcher	+42.70	+30
Turnstone	+18.80	-45
Greenshank	+73.56	+202
Redshank	+25.89	+408

Table 8.1: Comparative long term population trends for SCIs

8.1.2 Licence applications

8.1.2.1 Predicted Impact (alone)

In the absence of low tide count data, I-WeBS data, collected three hours either side of high tide, can be used to identify areas of importance based on the proportion of the Castlemaine Harbour SPA five-year mean of peak count for each SCI. However, the I-WeBS data is collected at too coarse a spatial scale to enable an impact prediction to be made at the spatial scale of the licence application or licence variation site. Each licence application will contribute however to an increase in the level of displacement and/or disturbance over baseline conditions. A study of waterbird usage at a scale commensurate with the spatial scale of the licence applications sites is required for a more refined impact prediction. This study should be coupled with an analysis of waterbird distribution over the part of the tidal cycle relevant to shellfish husbandry activities at Castlemaine Harbour and individual-based model to assess population consequences of progressively increasing levels of impact (Stillman and Goss-Custard, 2010).

Two licence variation applications (T06/291A, T06/304A) will not result in the increase in spatial extent or intensity of an existing licenced site. No appreciable habitat loss will occur for these two licence variation sites because they have previously been consented and the variation applications do not increase the maximum spatial extent of the shellfish culture area.

8.1.2.2 Predicted Cumulative Impact

All pending and new licence applications are predicted to cumulatively contribute to intertidal habitat loss in two I-WeBS subsites considered to be key area for maintaining the long term population trends of SCIs (Table 8.2). This cumulative loss is 15.8% of the total intertidal habitat within the I-WeBS count sectors (3785.2 ha) within Castlemaine Harbour SPA (intertidal extent = 4284.8 ha). The full exclusion of waterbirds from licence application or variation sites is not expected to be a universal response for either displacement from trestle areas (Gittings & O'Donoghue, 2012) or disturbance (Cutts *et al.*, 2009) for the species identified above (Table 8.3).

I-WeBS Subsite	Intertidal area occupied by new and pending application sites (ha) and the proportion of the total SPA intertidal area occupied [%]	Intertidal area occupied by existing and application sites (ha) and the proportion of the total SPA intertidal area occupied [%]

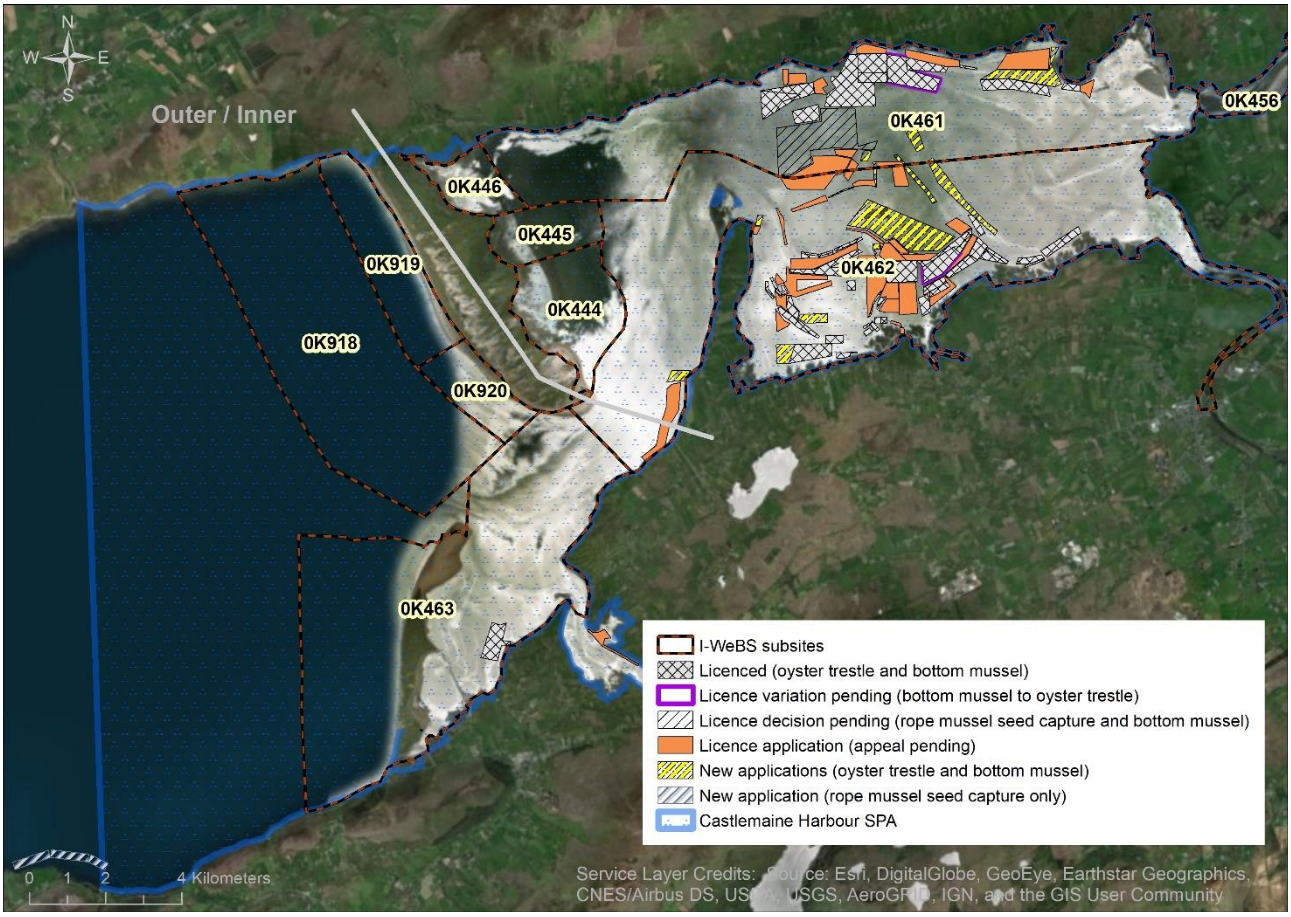
0K444	0.0 [0.0]	0.0 [0.0]
0K445	0.0 [0.0]	0.0 [0.0]
0K446	0.0 [0.0]	0.0 [0.0]
0K456	0.0 [0.0]	0.0 [0.0]
0K461	110.0 [2.9]	252.0 [6.7]
0K462	229.7 [6.1]	331.7 [8.8]
0K463	0.0 [0.0]	15.4 [0.4]
0K918	0.0 [0.0]	0.0 [0.0]
0K919	0.0 [0.0]	0.0 [0.0]
0K920	0.0 [0.0]	0.0 [0.0]
Total	**339.7 [8.9]**	**599.1 [15.8]**

Table 8.2: Extent of impacted intertidal habitat

When compared to the high level analysis of low tide data (NPWS, 2011a), the use of I-WeBS data produces a conservative approach in keeping with the precautionary principle. I-WeBS data identify all sectors that are directly affected by new and pending licence applications (0K461, 462) as key areas for supporting SCIs (see Figure 8.1 and 'S≥25%' in Table 8.3). By comparison, low tide data analysis by NPWS (2011a) also highlights five of the seven subsites that are directly affected by new and pending licence applications (0K448, 449 [overlap with core count subsite 0K461], 467, 468 and 469 [overlap with core count subsite 0K462]) as being of notable importance albeit for fewer SCIs (Table 4.2). This difference may reflect the higher resolution of the low tide subsites (i.e. small spatial scale; Figure 2.1) compared to the I-WeBS subsites which would have the effect of pooling bird numbers over a wider area (Figure 8.1). Further precaution is included in the prediction because within an intertidal area some areas are favoured more than others (Gittings & O'Donoghue, 2011), i.e. the distribution may be clumped.

All licence applications are predicted to cumulatively occupy 9.2% (0K461) and 19.9% (0K462) of the intertidal habitat in each of the I-WeBS subsites (Table 8.3). In the absence of evidence to the contrary, i.e., trestle plans for each licence application and site access management between sites, it is assumed that displacement or disturbance may conservatively result in no less than 5% exclusion cumulatively from the licence application or variation sites in each I-WeBS subsite. At some times, these impacts acting synergistically may result in full exclusion from a licence application or variation site.

Figure 8.1: Castlemaine I-WeBS Subsites



Species	Criterion		
	1 (S≥25%)	2 (P≤-25 & S≥5%)	3 (P≤-25 & S≥5% = P+S ≤-25)
0K461			
Mallard	33%	N/a	N/a
Oystercatcher	54%	N/a	N/a
Ringed Plover	141%	N/a	N/a
Sanderling	133%	N/a	N/a
Bar-tailed Godwit	96%	N/a	N/a
Greenshank	173%	N/a	N/a

Redshank	86%	N/a	N/a
Turnstone	N/a	N/a	-88(P)+18(S)=-70
0K462			
Mallard	30%	N/a	N/a
Oystercatcher	34%	N/a	N/a
Ringed Plover	42%	N/a	N/a
Greenshank	34%	N/a	N/a
Redshank	35%	N/a	N/a
Turnstone	128%	N/a	N/a

Table 8.3: Castlemaine Harbour I-WeBS subsites of importance to SCIs

8.1.2.3 Predicted In Combination Impact

Only two pending licence variation sites (T06/291A and T06/304A) can be assessed in combination with recreational disturbance because the predicted impact alone or cumulatively have been excluded.

8.1.3 Access Routes

8.1.3.1 Predicted Impact (alone)

All five of the access routes (Figure 8.2 and Figure 8.3) are located within 500m of a high tide roost. Intertidal shellfish cultures will be accessed within two to three hours either side of low tide and therefore the use of these access routes will not coincide with the formation of high tide roosts. Use of the access tracks within two hours either side of high tide should be restricted.

Figure 8.2: Access routes and high tide roosts: Killorglin to Cromane

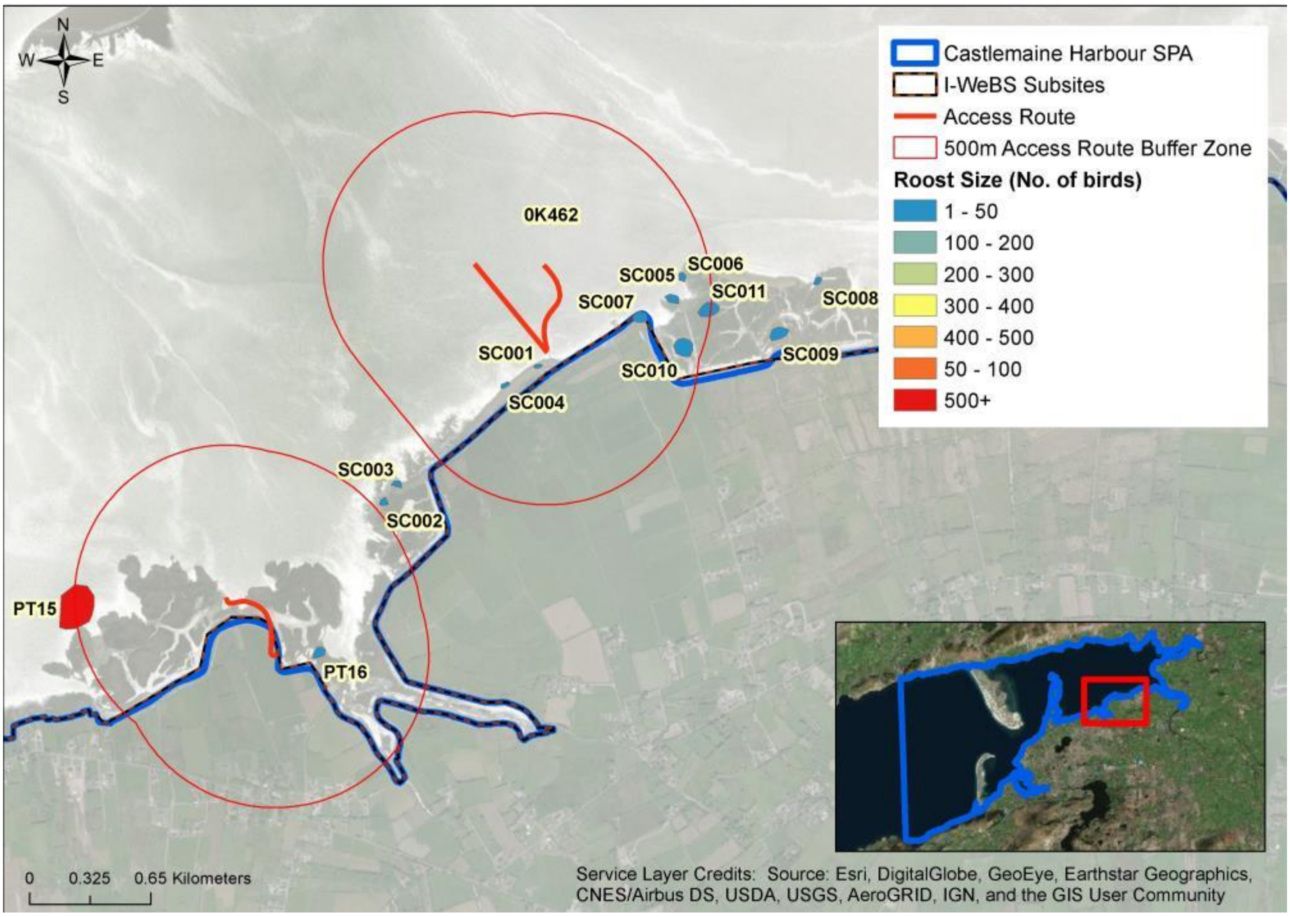
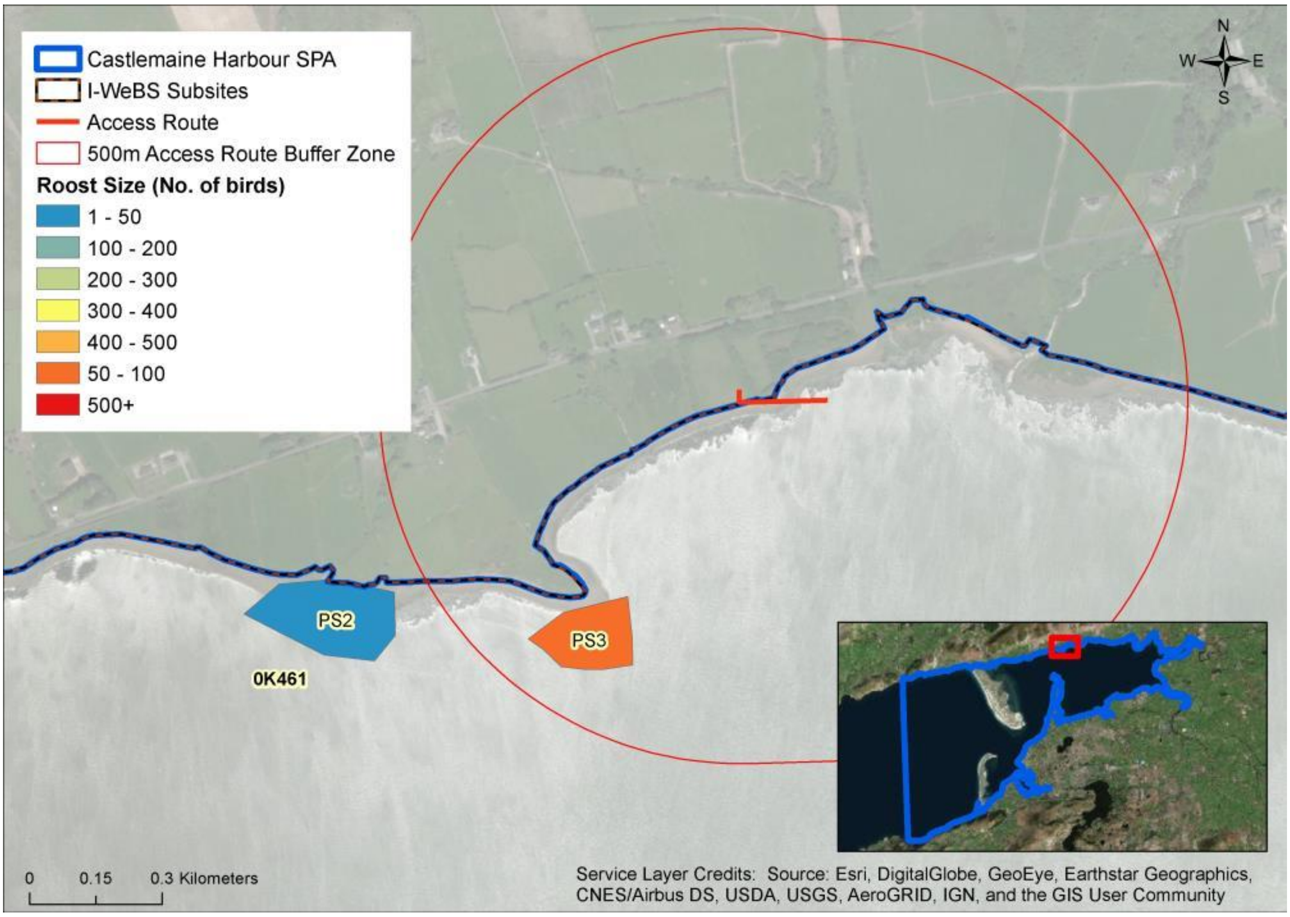


Figure 8.3: Access routes and high tide roosts: Laughtalla to Inch



8.1.3.2 *Predicted In Combination Impact*

Disturbance of high tide roosts from the use of access routes will not occur and therefore no in combination impacts are anticipated.

8.2 Conservation objectives

It is important to "assess whether there will be adverse effects on the integrity of the site as defined by the conservation objectives and status of the site" (European Communities, 2002). For those new and pending licence applications where an impact is predicted, the effects of disturbance and displacement is considered to be lasting, in so far as the effects are not small scale (likely to occur over 9% of the SPA intertidal area) and would not recover for the duration of the licenced period (10 years).

On the basis of the evidence presented above for those new and pending licence applications where an impact is predicted, an adverse effect cannot be excluded because the consenting of the licence applications will:

- Cause delays and interrupt progress towards achieving the conservation objectives of the site for those species in long term population decline;
- Disrupt those factors that help to maintain the favourable conditions of the site (i.e. spatial extent of functional habitat);

- Interfere with the distribution and density of SCIs that are the indicators of the favourable condition of the site (i.e. caused be displacement);
- Cause changes to the vital defining aspects (i.e. undisturbed foraging areas and an absence of obstructions to sight lines) that determine how the site functions as a supporting habitat for waterbirds;
- Reduce the area of key habitats;
- Result in disturbance that could affect population size or density or the balance between key species;
- Result in habitat fragmentation;
- Result in loss or reduction of key features (i.e. an absence of obstructions to sight lines).

Objective 1 - To maintain the favourable conservation condition of the waterbird Special Conservation Interest species listed for Castlemaine Harbour SPA (NPWS, 2011b).

For the new and pending licence applications (cumulatively), a significant decrease in the numbers or range of areas used by waterbird species cannot be excluded.

Objective 2 - To maintain the favourable conservation condition of the wetland habitat at Castlemaine Harbour SPA as a resource for the regularly-occurring migratory waterbirds that utilise it (NPWS, 2011b).

The new and pending licence applications (cumulatively), will result in the permanent area occupied by functional intertidal habitat (for foraging waterbirds) to less than 3983 ha, i.e. 3186.1 ha. Applying an 'all-projects' approach to cumulative impacts, means that all licence application sites, including licence variations, could be regarded as having an adverse effect on site integrity.

Using a building blocks approach and whilst taking into account the existing licenced sites as part of baseline conditions,, all Tier 1 (existing consented licences) and Tier 2 (pending licence variation applications) sites plus new licence application T06/493A (subtidal mussel rope) would result in 'no result in an adverse effect in site integrity alone, cumulatively or in combination' because:
- The spatial extent of the existing and variation sites has not changed;
- The predicted impact for T06/493A is not appreciable and is spatially and temporally separated from other sources of disturbance; and
- The baseline level of disturbance is considered to be the same as that described by NPWS (2011a).

In the absence of more accurate impact predictions based on additional studies and population modelling, an adverse effect on site integrity cannot be excluded alone, cumulatively or in combination for all Tier 3 (new and pending application) sites. This determination is based on the fact that:

1. The cumulative spatial extent of the new and pending licence application sites is such a large proportion of Castlemaine Harbour SPA (9% of the intertidal habitat alone); and
2. There is insufficient data to determine a threshold whereby the cumulative impact of application sites could be 'built-up' by consenting applications to a point before an adverse effect on site integrity was beyond reasonable scientific doubt.

8.3 Mitigation measures

With a preference for avoidance or minimisation at source (European Communities, 2000), the application of the mitigation hierarchy through a spatial planning approach can manage most of the potential environmental impacts of aquaculture projects (European Commission, 2012). Such an approach allows the competent authority, in accordance with European guidance (European Communities, 2002), to determine what level of mitigation is required whilst taking into consideration the opinion from the relevant nature conservation authorities and NGOs as well as the licence applicant.

In accordance with European guidance on aquaculture in Natura 2000 sites mitigation should be "technically feasible solutions that are the least damaging for habitats, for species and for the integrity of the Natura 2000 site, especially if alternative locations are not feasible” (European Commission, 2012). Furthermore, the description of identified mitigation measures should contain the following key information:

- Details of each of the measures proposed and an explanation of how it will avoid or reduce the adverse impacts which have been identified;
- Evidence of how they will be implemented and by whom;
- A timetable for implementation relative to the plan or project (some may need to be put in place before the development can proceed); and
- Details of how the measure will be monitored and how the results will be fed back into the day-to-day operation of the aquaculture project (European Commission, 2012).

In the case of Castlemaine Harbour SPA no such strategic approach currently exists and although mitigations are an integral part of a project, none of the new or pending licence applications include any proposals for mitigation measures. There is not sufficient confidence that the affected areas within Castlemaine Harbour SPA will maintain a comparable level of ecological functionality if the licences were consented.

Whilst taking into account the existing licenced sites as part of baseline conditions, only the two licence variation applications and one new application for subtidal mussel rope culture could be consented at this time. No further consenting of licence applications should take place until such time that additional studies are completed and mitigation approaches considered.

The pending application decision site for combined rope mussel seed capture and bottom mussel cultivation (TA06/457) can be consented at this time only if bottom mussel cultivation is not included in the application.

Mitigation measures can only realistically be defined once you know the magnitude of the impact of individual licences can be measured; at the time of writing this is not possible. Following more detailed analysis of the predicted impacts by individual-based models supported by updated low tide count data, mitigation options that could be considered include:

- Avoiding areas important to special conservation interests;
- Minimising the density of licence applications;
- Minimising the number of trestles present within each licence area;
- Co-ordinating operational activities to ensure adequate functional foraging habitat is available during operational days.

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