Report supporting Appropriate Assessment of the impact of seed mussel fishing and relaying on Castlemaine Harbour SAC and SPA

April 2016

Marine Institute
Rinville
Oranmore

Contents

Section 1 - Introduction

This document assesses the potential ecological impacts of fishing and relaying of mussels (*Mytilus edulis*) in and adjacent to Castlemaine Harbour SAC and SPA (Natura site) on the conservation objectives and special conservation interests of the Natura site. The information upon which this assessment is based is the 10 year mussel seed Fishery Natura Plan (FNP) submitted, by the Castlemaine Mussel Producers Co-operative, to the Department of Agriculture Food and Marine (DAFM) in 2016. The activity involves the fishing for seed mussel in inner Dingle Bay or in Castlemaine Harbour, the relay of seed onto intertidal habitats in the area covered by a Fishery Order previously issued to the co-operative and the relay of half grown mussels from the intertidal area to sub-tidal habitats. Some seed may be re-laid onto intertidal and sub-tidal sites licenced for mussel Aquaculture.

The AA is supported by a number of Annexes which contains detailed technical information in support of the conclusions in the assessment.

- **Annex I**. The seed mussel fishery Natura plan 2016-2026
- **Annex II**. Intertidal benthos in relation to mussel relay
- **Annex III**. Subtidal benthos in relation to mussel relay
- **Annex IV**. BIM Castlemaine seed mussel survey report of 2014
- **Annex V**. Gittings and O'Donoghue 2011a. Castlemaine waterbird studies I. Mussels
- **Annex VI**. Notes on Common Scoter at Dingle Bay (M. O'Clery 2011)
- **Annex VII**. Gittings and O'Donoghue 2011b. Castlemaine waterbird studies II. Oysters
- **Annex VIII**. Gittings and O'Donoghue 2011c. Castlemaine water birds studies III. Clams
- **Annex IX**. Effects of human disturbance on waterbirds

Section 2 - Details of the proposed operations/activities

1. Fishing for seed mussel

Target species:

- Blue mussel (*Mytilus edulis*)

Location:

- The proposed activities are described in the draft mussel fishery Natura plan (2016-2026) (Annex I) and below.
- The fishery plan is primarily concerned with the dredging and relaying of seed mussel in a number of areas within the Castlemaine Harbour SAC (IE000343) and (SPA IE 4029).
- The applicants are members of the Castlemaine Harbour Co-operative Society Ltd. who hold the Mussel Fishery Order for the area from 1979 and whose members also hold aquaculture licences in the Harbour east of the Mussel Fishery Order.
- There are three distinct phases in the production of mussels in Castlemaine
    - seed dredging
    - inter-tidal nursery
    - sub-tidal on-growing and subsequent dredging for harvest
- Seed dredging is licensed through fisheries legislation and occurs outside of Castlemaine Harbour. All mussel dredgers fishing seed are registered and licensed as Aquaculture fishing vessels. In addition the vessels require annual authorizations and seed mussel allocations, to fish mussel seed, from DAFM along with the relevant movement authorisations (from Marine Institute).
- The catch from the seed fishery is relayed onto the intertidal area and subsequent transfer to sub-tidal areas inside Castlemaine Harbour prior to harvesting

Duration:

The seed mussel Draft Fishery Natura Plan is for the period 2016-2026 inclusive.

Seed mussel dredge fishery

- The proposed seed mussel fishery is described in the Draft Fishery Natura Plan developed by the applicants (Annex I) and will be based on demonstrated availability of seed mussel in the area as determined by annual seed mussel stock surveys undertaken by Bord Iascaigh Mhara (BIM).
- The location of settlement of seed mussel varies annually. The fishable area in the fishing plan is 555ha (Figure 1). In any given year the seed bed covers only a percentage

of the fishable area at the mouth of the Castlemaine Harbour. Although the fishery plan describes an area along the north shore of the Harbour as a potential mussel seed bed it does not incorporate this area formally into the plan but indicates that a review of the plan could be initiated if a seed bed did occur there. This area is, therefore, not included in this appropriate assessment. Other areas, where seed may fall, and which are described in the plan as areas unsuitable for fishing, are also not considered in this assessment.

- The dredges used in the fishery are 2m mussel dredges with a flat bar that is designed to skim the surface of the substrate and separate mussel seed from the underlying sediment. Five or 6 vessels >20m but potentially up to 9 such vessels, and 9-10 but possibly up to 20 small vessels (<15m) may apply for permits to fish for seed. Seed fishing permits and allocations are issued by DAFM. Operationally dredging can only occur over neap tides and will usually occur in spring and/or autumn following sufficient growth of the seed and prior to predation by starfish and/or potential washout by autumn storms. Autumn fisheries are more usual in Castlemaine as seed are too small to harvest in Spring
- A maximum of 5000 tonnes, inclusive of all sources, will be relayed into the intertidal area of Castlemaine Harbour annually. The intention of the fishery plan is to source this seed from the area outlined in the plan but where necessary and where seed is not available or where the biomass is low then seed may be sourced from the Irish Sea. The potential impact of fishing for seed mussel in the Irish Sea is not included in this assessment. Fishing for seed mussel in the Irish Sea by the Irish fleet generally was separately assessed in 2014.The potential impact of seed relay is independent of the source of the seed other than the need for monitoring of the presence of alien species which might occur in seed from some source. This risk is assessed through an alien species monitoring programme.

Relaying of seed mussel on the inter-tidal sand flat

- Seed mussel caught during fishing will be transferred, within a few hours of being fished, to an inter-tidal nursery site (111ha) where they will remain for 6 to 12 months (Figure 1). It may be retained here for longer than 12 months if sub-tidal mussel stocks have not been harvested as planned (due for instance to biotoxin closures which prevent harvesting). The intertidal nursery area may also extend eastwards to the low water spring mark and therefore be larger than 111ha. The seed is transplanted by pumping it, mixed with seawater, from the hold of the boat onto the nursery and grow out plots. The vessels are fitted with a pumping system. This pattern of relaying is achieved by the vessels moving across the plots during pumping in an effort to achieve an even distribution of mussel on each plot in order to maximise survival and growth. Pumping pressure is variable but does not disturb sediments and is undertaken at high tide in

water depths of 3-4m.

- Once the seed has been relayed, there is no activity on the nursery areas apart from checking the seed. A co-op member will walk the nursery area once a fortnight, on spring tides, to check the condition of the seed.

Harvesting from the inter-tidal sandflat

- Previously re-laid mussels will be dredged from the intertidal area 6-12 months following relay and deposited for on-growing on the sub-tidal area of the fishery order currently utilised by the co-op and also onto aquaculture sites (Figure 1).
- Intertidal dredging does not result in removal of all mussels from the sandflat; the dredging process is not 100% efficient. Patches of mussel that remain in the intertidal area grow, mature and usually become overgrown with seaweed (*Fucus* spp).

Relaying on and dredging from the sub-tidal channel

- Licensed mussel vessels and a number of licensed punts relay the half grown mussels by either pumping it mixed with seawater from the hold of the boat onto the grow out plots or manually loading and unloading from the intertidal to the sub-tidal area.
- This activity takes approximately 28 days activity over a six month period in spring and summer.
- Mussels are harvested, to order, by vessels from the sub-tidal plots. The owners only remove market sized mussels from the sites after the grow-out period and if orders have been placed with their companies. All harvesting and sales activity is monitored by the SFPA through gatherers documents, VMS plotting and at licenced distribution and depuration centres. Larger vessels do most of the harvesting and require a few hours of activity at high water to harvest 30 tonnes.
- No waste is generated as the harvested product is placed directly into one tonne bags for export, via refrigerated truck from Cromane.

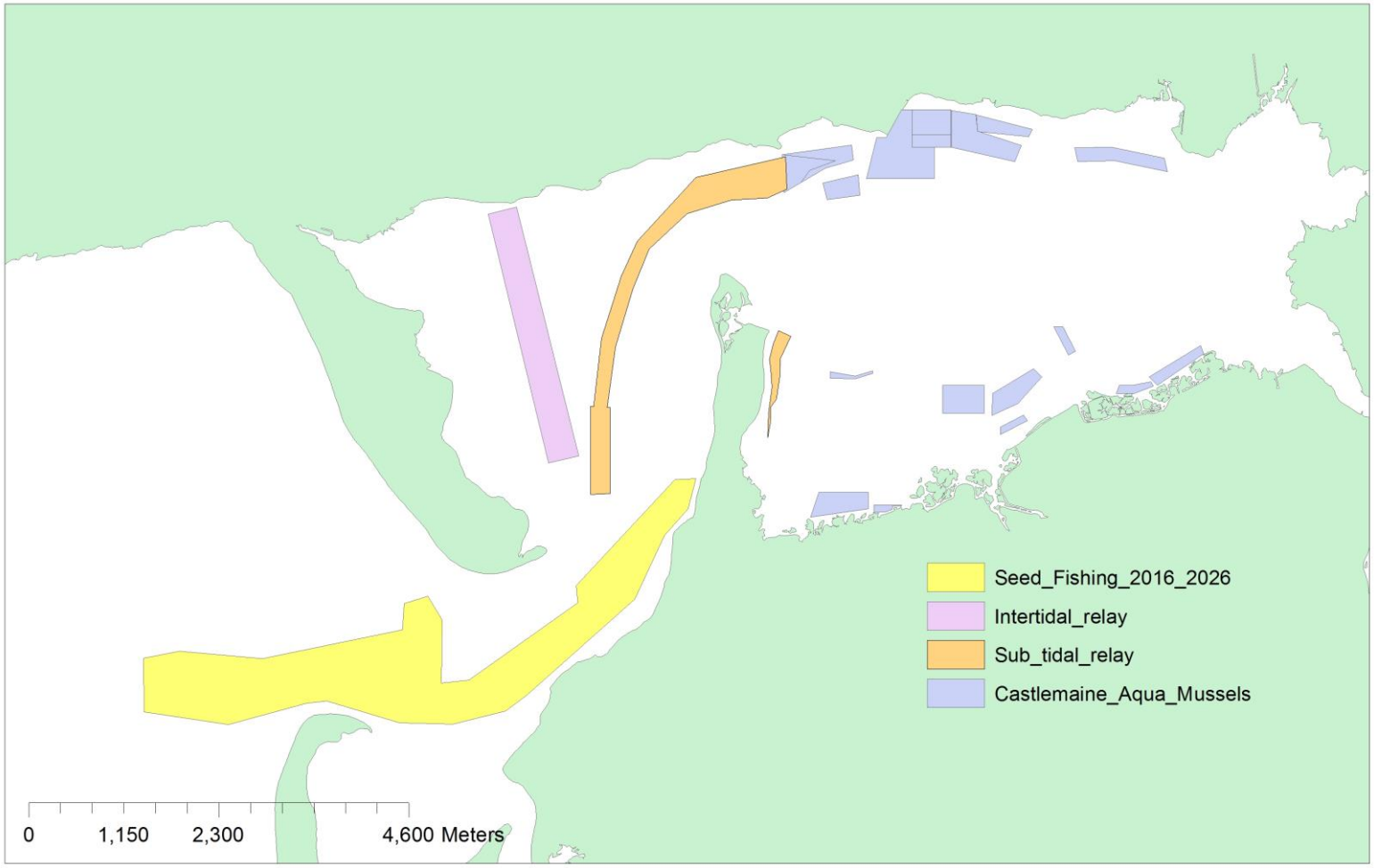

Figure 1. Location of proposed seed mussel fishing , intertidal relay of seed mussel and sub-tidal relay of mussels and licenced mussel aquaculture sites within Castlemaine Harbour.

2. Activities with potential in combination effects

Aquaculture of oysters

Intertidal culture of the Pacific oyster (*Crassostrea gigas*) is licenced in Castlemaine Harbour. A total of 28 areas are licenced occupying an area of 82 hectares. Recent annual production has totalled to approximately 250 tonnes (Figure 2).

Pacific oysters are usually grown in plastic mesh bags secured to metal trestles in the inter-tidal zone. The bags are held (suspended) above the substrate in order to allow free movement of water above and below the oysters.

Seeding/ Seed Source

Seed or 'spat' oysters are purchased from hatcheries. They are available in a variety of size grades, usually from 4-30mm shell length. The size grade quoted by suppliers generally refers to the size of mesh used to sort the oyster seed (3 – 14 mm mesh). Seeding is generally carried out in spring-time when seed (> 5g or 10-15mm) becomes available from hatchery. Oysters in Castlemaine are sourced primarily from hatcheries in France or the UK. The majority of seed is triploid with some acquiring a mix or both triploid and diploid seed.

Seed was historically purchased on an annual basis between April and June (sometimes in March). More recently, however, seed has also been introduced between October and November. This is due to a combination of factors; there has been a shortage of seed in recent years and to minimise mortalities growers bring in seed in autumn to harden it over the winter in the hope that it will be more resilient during the following summer. In addition, some growers are now looking to sell stock year round and therefore wish to have market sized animals available to fulfil this goal. Sites are generally accessed on every suitable tide (1/fortnight) for checking but bag turning takes place on the extreme low tides between march and November averaging 6 times/ year at each site.

Grading and Thinning and Growout

Where oysters are grown in bags to harvest, the size of the mesh in the bags is increased progressively as the oysters grow. Oyster seed between 4 - 8 mm shell-length is generally placed in 2 mm mesh bags. At 8 – 15 mm shell-length 4 mm mesh is used. From 15 – 25 mm shell-length the bag is usually of 7 – 8 mm mesh and above 25 mm shell-length 14 mm mesh is used. By final harvest the bags are generally of 18 – 25 mm mesh. As general rule

the largest mesh that will still retain all the stock is used as this promotes good water flow and optimises growth.

The density of the stock within the bags is also reduced progressively as the animals grow. In Castlemaine, grading takes place 2-3 times during the growth cycle. After the first 8-12 months depending on intake size, intake time and general growing conditions, oysters are repacked at a density of approximately 1000 pieces / bag. Depending on growth second grading may take place the following autumn to 500 pieces / bag. The final grading repacks the oysters at a density of averaging 150 pieces /bag. For stock grown over 2.5 years this takes place in springtime.

Harvesting

Harvesting is carried out predominantly during the months of November, December and January. The stock is harvested when they attain suitable size and condition. This can be from 75g (>85mm) upwards. It can take 2.5 – 3 years to first harvest. However, as indicated above harvesting can also occur at other times of the year to fulfil market demands.

Site access

Sites are generally accessed on every tide (once per fortnight) for checking but bag turning takes place on the extreme low tides between March and November averaging 6 times/ 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.

Aquaculture of clams

Clam (*Ruditapes philipinnarum*) culture is carried out at a single site within Castlemaine Harbour SAC/SPA (Figure 2). The site is 16 hectares in area. Clam seed are planted in the spring. Seed bought from hatchery from July - September - 8-10 million (Size 2mm). The seed is placed in Nursery trays on-site for approx 1 year. Thinned every 6-8 weeks (it takes 1 day per million). Within each nursery frame approximately 1million seed is planted and as it grows it is thinned out until such a time as it is required for planting. By this time 6 trays are required for each $1x10^6$ clams. In total 48 nursery tray are utilized. Seed is only planted on Spring Tides. Planting of same seed following July-September, seed has to reach 8-10mm before it can be planted. No further thinning is carried out when seed is planted.

Seed is planted directly in the seabed and overlain with a net. The netting is automatically laid with a tractor. Maintenance and cleaning of the net is only carried out on a spring tide

when accessible, and conducted using brushes which are towed by a tractor.

Harvesting takes place throughout the year depending on demand but on Spring Tides only. Harvesting is done by mechanical harvester.

During grading, thinning and harvest the seed is brought to higher intertidal areas within the site to allow more time to work on grading, but it must also be left in the water for as long as possible, as the young clam seed is very fragile. When seed is purchased from the hatchery it is only 2mm. Also when harvesting, grading is carried out on site, so clams can be put back in the water in trays to train (open and close in response to tidal cycle) and allowed to recover from stress caused by harvesting.

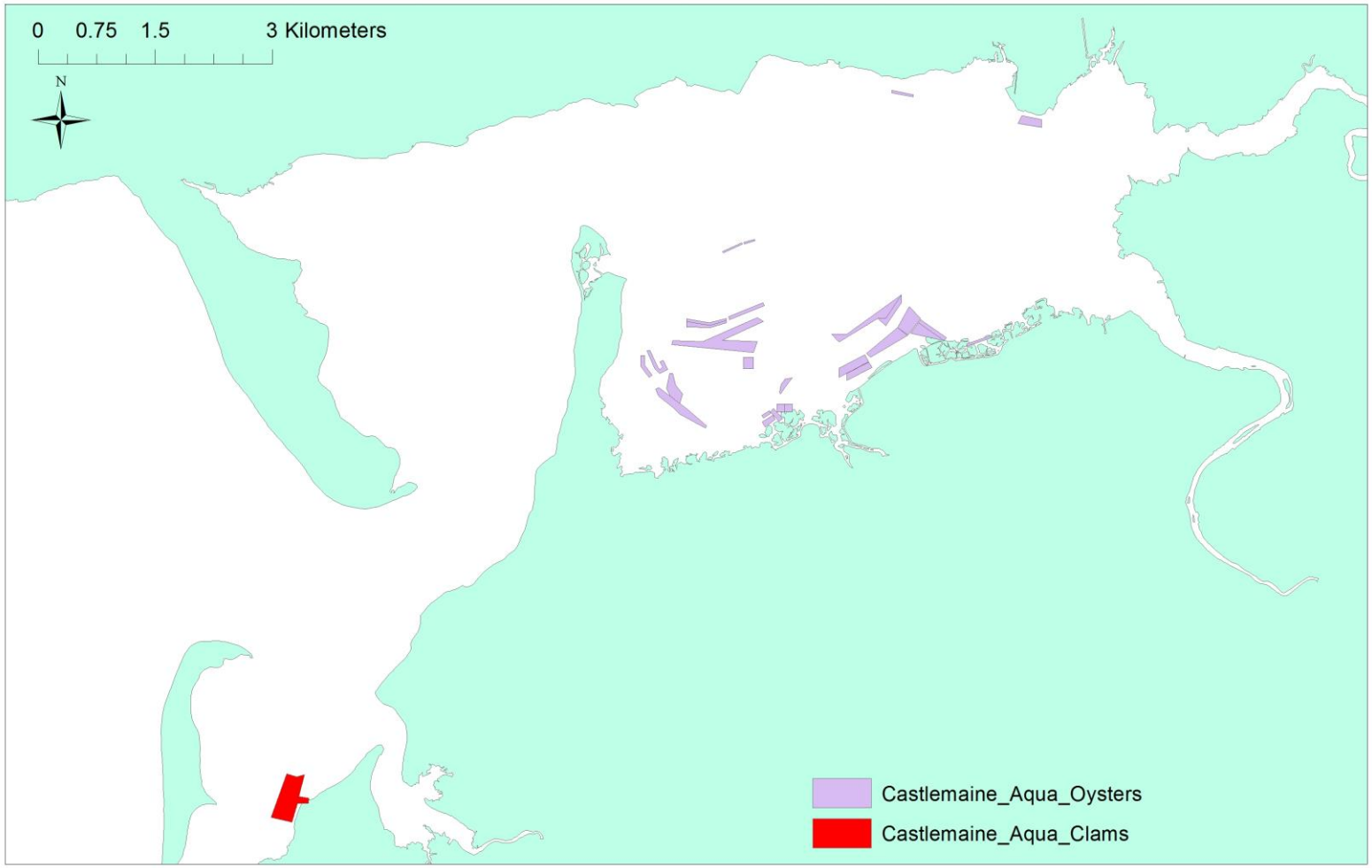

Figure 2. Areas licenced for oyster and clam aquaculture within Castlemaine Harbour

Crab Predator control

Up to 6 punts are engaged in predator control in the seed mussel intertidal nursery area throughout the year. Baited traps are laid in lines of 11 strings of 25 pots per string. The pots are left to fish for 24 hours and hauled every day weather permitting. Approximately 300 tonnes of green crab are extracted annually and sold on the commercial market.

Periwinkle picking

Commercial picking of periwinkles occurs in intertidal areas of Castlemaine Harbour at low tide. The location, quantity of activity generated and total out-take is unknown.

Cockle harvesting

Commercial hand raking of cockles occurs in an area to the north east of the clam aquaculture site. One gatherer is involved. The activity occurs at low tide every week.

Effluent Discharge (WWTPlants)

Currently there are 5 wastewater treatment plants operating in the general vicinity of the Castlemaine SAC/SPA. The following infrastructure and treatment is in place:

Castlemaine: The EPA issued a Certificate of Authorisation for Castlemaine WWTP in May 2011. Irish Water is currently reviewing a number of options for the treatment of wastewater from this plant including; pumping to Milltown and upgrading existing system

Glenbeigh: Glenbeigh is served by 800 p.e. secondary treatment WWTP. The EPA issued a Wastewater Discharge Licence for Glenbeigh WWTP in Jan 2015 with emmission limits of 25mg/l BOD, 125mg/l COD, 35mg/l SS, 5mg/l Ammonia and 2mg/l Ortho-P.

Killorglin: Killorglin is servied by a 5000 p.e. secondary treatment plan. Estimated loading on the plan is approx 3900 p.e.. The plant consistens fo fine screen, grit removal, storm water settlement tank, carousel oxidation ditch and 2 secondary treatment tanks. The EPA issued a Wastewater Discharge licence for Killorglin in June 2015 with ELVs of 25mg/l BOD, 125mg/l COD, 35mg/l SS, 5mg/l Ammonia and 2mg/l Ortho-P.

Milltown: A new 3500 p.e. secondary treatment to serve Milltown has been operational sicne May 2011. The EPA issued a Wastewater Discharge Licence to the Milltown WWTP in August 2015 with emission limit values of 25mg/l BOD, 125mg/l COD, 35mg/l SS and 5mg/l Ortho-P.

Rossbeigh: The EPA has issued a Certificate of Authorization (CoA) for Rossbeigh. Since

the CoA was issued Kerry CoCo converted the original primary settlement tank to a pumping station which pumps untreated effluent to a new 350 p.e. design capacity integrated Constructed Wetland for treatment before being discharged.

Recreation

The area supports a variety of recreational activities including bird-watching, walking, horse riding, recreational off road vehicles, angling, sailing and windsurfing (NPWS 2011b).

3. Trends in production of mussels, oysters and clams in Castlemaine Harbour

Mussels

- Mussels have been produced from Castlemaine Harbour for many decades. Records from 1966-2014 (Figure 3) show strong fluctuations in production between years. This is presumably due to variability in seed supply, in seed survival during on-growing and probably the market demand and activity of the members of the co-operative. Production peaked at over 8000 tonnes in the early 1980s and at 7000 tonnes in the late 1980s. Smaller peaks in production occurred in 1996 and 2003. From 2003 to 2013 production generally declined. Implementation of the first seed mussel fishery natura plan 2011-2015, in combination with additional mussel aquaculture licences issued during this period, did not lead to significant increases or changes in production levels. This plan envisaged harvesting between 2000-5000 tonnes of seed and that final market production volumes would be similar to this given a 1:1 ratio between seed relay and final harvest. The production figures 2011-2015 are below or at the lower limit of these estimates. The 2016-2026 plan for a maximum of 5000 tonnes of seed relay could lead to increased production if seed volumes were at this level every year. This is unlikely and the production over the period 2016-2026 is very likely to be within the historic range and lower than the peaks in production seen in the 1980s.

Oysters

- Oyster production increased from 136 tonnes in 2011 to 250-260 tonnes in 2014 and 2015 (Table 1). This increase is consistent with the additional licences issued for oyster during this period following the 2011 Appropriate Assessment of fisheries and aquaculture in Castlemaine. Market demand for oysters has also been strong during this period. Site usage and occupancy (% of the sites occupied by trestles) at these levels of production however are still relatively low. There are conditions attached to the licences regarding escalation in productin and site usage that this should be incremental and run in parallel with bird monitoring programmes.

Clams

- One site is licenced for production of clams (*Ruditapes philippinarum*). The site is also licenced for oysters. An estimated 25 tonnes of clams were produced in 2011 but there was no production in subsequent years.

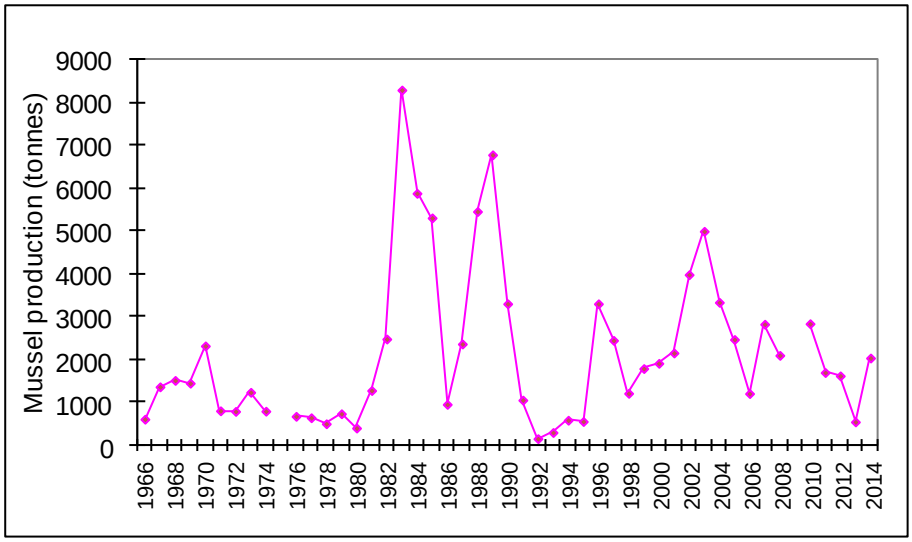

Figure 3. Trends in mussel production in Castlemaine Harbour 1966-2014.

Table 1. Clam and oyster production in Castlemaine Harbour 2011-2015.

Year	Species	Tonnes
2011	Clam	25.0
2012		0.0
2013		0.0
2014		0.0
2015		0.0
Total		**25.0**
2011	Gigas Oyster	136.0
2012		150.0
2013		177.3
2014		259.9
2015		252.9
Total		**976.1**

Section 3 - Conservation objectives

1. Qualifying interests in the Special area of Conservation

Castlemaine Harbour Special Area of Conservation (site code IE 000343)

All qualifying interest(s):

- 1095 Sea lamprey (*Petromyzon marinus*)
- 1099 River lamprey (*Lampetra fluviatilis*)
- 1106 Salmon (*Salmo salar*)
- 1130 Estuaries with the community types outlined in Table 2 and Figure 4.
- 1140 Mudflats and sandflats not covered by seawater at low tide with the community types outlined in Table 2 and Figure 4
- 1210 Annual vegetation of drift lines
- 1220 Perennial vegetation of stony banks
- 1310 Salicornia and other annuals colonizing mud and sand
- 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
- 1355 Otter (*Lutra lutra*)
- 1395 Petalwort (*Petalophyllum ralfsii*)
- 1410 Mediterranean salt meadows (*Juncetalia maritimi*)
- 2110 Embryonic shifting dunes
- 2120 Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)
- 2130 Fixed coastal dunes with herbaceous vegetation (grey dunes)
- 2170 Dunes with *Salix repens* ssp. *argentea* (*Salix arenariae*)
- 2190 Humid dune slacks
- 91E0 Alluvial forests with Alnus glutinosa and Fraxinus excelsior (*Alno Padion*, *Alnion incanae*, *Salicion albae*)

The distribution of inter-tidal biological communities within Castlemaine Harbour is closely related to exposure levels and sediment types (Figure 4). In addition, there is a strong influence of both river channels (River Maine to the north and the River Laune to the south) within the main harbour, in addition to the Caragh River, which drains into Rossbehy Creek, on the distribution of estuarine communities within Castlemaine Harbour.

Table 2. Marine communities within habitat 1140 (Mudflat and sandflat not covered by seawater at low tide) and 1130 (Estuaries) in Castlemaine Harbour (NPWS 2011a)

Habitat	**No.**	**Community**	**Characterising species**	**Area (Hectares)**
1140	1	Intertidal muddy fine sand community complex.	*Tharyx sp A, Polydora cornuta, Gammarus locusta, Macoma balthica, Hediste diversicolor, Corophium volutator, Heterochaeta costata, Pygospio elegans, Crangon crangon*	*554*
1140/1130	2	Fine to muddy fine sand with polychaetes community complex	*Pygospio elegans, Eteone longa, Scoloplos armiger, Spio martinensis, Macoma balthica, Capitella capitata, Angulus tenuis*	*3555*
1140/1130	3	Intertidal sand with *Nephtys cirrosa*	*Nephtys cirrosa, Bathypoeia pilosa, Scolelepis squamata*	*861*
1140/1130	4	*Zostera* dominated community	*Zostera sp.*	*234*
1130	5	Mixed sediment community complex	*Mytilus edulis, Corophium acherusicum, Caprella acanthifera, Pholoe synophthalmica, Nemertea indet, Pomatoceros lamarckii, Microprotopus maculatus, Abludomelita obtusata, Amphipholis squamata, Jassa pusilla, Eumida sanguinea, Nephtys cirrosa, Ammothella longipes, Angulis tenuis, Gastrosaccus spinifer*	*588*
1140	6	Fine sand with *Donax vittatus* and polychaetes community	*Donnax vittatus, Spiophanes bombyx, Magelona mirabilis etc.*	*5*

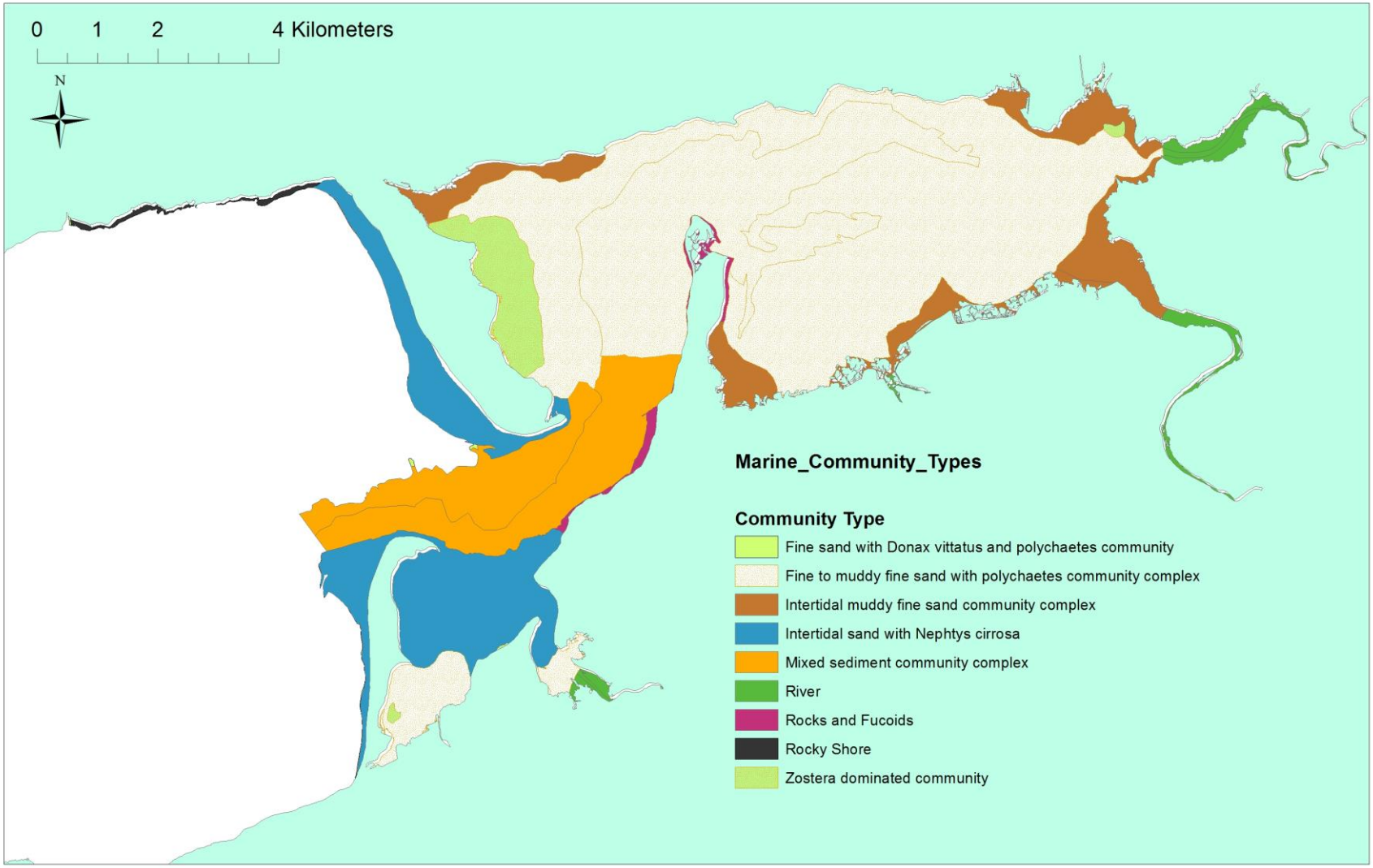

Figure 4. Distribution of inter-tidal and subtidal benthic marine communities in Castlemaine Harbour.

2. Conservation objectives for the SAC

- NPWS (2011a) provide a description of the conservation objectives for all qualifying interests of the SAC.
- The proposed mussel production activity overlaps habitat 1130 (Estuaries) and 1140 (Mud and sand flats not covered by seawater at high tide) in particular.
- In the case of marine communities within Habitats 1130 and 1140 the important attributes that must be conserved are Habitat area and Habitat structure and function.
- Habitat area: The likely area occupied by the constituent communities of Habitats 1130 and 1140 should be stable or increasing with overall target areas of 5696ha and 4287ha respectively
- Habitat structure and function: The communities of habitats 1130 and 1140 should be stable in distribution and species composition (as outlined in Table 2).
- Licensing of activities likely to cause continuous disturbance of each community type should not exceed an approximate area of 15%. Thereafter, an increasingly cautious approach is advocated (NPWS 2011a). Disturbance is defined as activities that result in change to habitat are, structure or function. Disturbance may be continuous or episodic or temporary or occur at a given frequency. Such patterns of disturbance may enable habitats to recover between disturbance events and be in favourable conservation status generally. In these cases more than 15% of the habitat could be temporarily disturbed but no cumulative effects may occur due to recovery between disturbing events. These situations should be assessed case by case having regard to the sensitivity of the receiving environment and the nature of the disturbing activity.

3. Conservation Interests in the SPA

Special Conservation Interests for Castlemaine Harbour Special Protection Area (site code IE 4029) are:

- A001 Red-throated Diver (*Gavia stellata*)
- A017 Cormorant (*Phalacrocorax carbo*)
- A046 Light-bellied Brent Goose (*Branta bernicla hrota*)
- A050 Wigeon (*Anas penelope*)
- A053 Mallard (*Anas platyrhynchos*)
- A054 Pintail (*Anas acuta*)
- A062 Scaup (*Aythya marila*)
- A065 Common Scoter (*Melanitta nigra*)
- A130 Oystercatcher (*Haematopus ostralegus*)
- A137 Ringed Plover (*Charadrius hiaticula*)
- A144 Sanderling (*Calidris alba*)
- A157 Bar-tailed Godwit (*Limosa lapponica*)
- A162 Redshank (*Tringa totanus*)
- A164 Greenshank (*Tringa nebularia*)
- A169 Turnstone (*Arenaria interpres*)
- A346 Chough (*Pyrrhocorax pyrrhocorax*)
- A999 Wetlands & Waterbirds

4. Conservation Objectives for the Special Protection Area

NPWS (2011b) provide a description of the conservation objectives and targets for species of waterbirds and the wetlands which support them.

1. Population trends and Distribution, as measured by the % change in population size and the numbers of birds and range of areas used, should be stable or increasing. In particular populations would be classified as being in unfavourable status if they declined by more than 25% in the most recent 5 year period.

2. The area of subtidal, intertidal and supratidal habitats should be stable or increasing and not less than the areas of 7471, 3983 & 312 hectares for sub-tidal, intertidal and supratidal habitats, respectively other than that occurring from natural patterns of variation.

Section 4 - Natura Impact Statement

1. Ecological effects

- The potential generic ecological effects on the qualifying interests of the site relate to the physical and biological effects of dredging and culture of shellfish species which overlap with invertebrate communities found in inter-tidal and sub-tidal habitats (Figure 5).

- Bird populations may also be affected by these habitat changes and by disturbance caused by fishing vessels, by human disturbance on the shore associated with shellfish production and also by changes in the availability of prey species as a result of changes in habitat brought about by shellfish production. Birds use the area for foraging and roosting. Foraging occurs throughout the intertidal area with individual species preferences for particular habitats. Dot maps showing distribution of different species of birds at low tide in sections of the Harbour are in NPWS (2011b). Roost locations at high tide in relation to the location of shellfish production activities are shown in Figure 6.

- Details of potential ecological effects of each activity described above, on the SAC and SPA conservation objectives, their sources and the mechanism by which the impact may occur are provided in Table 3.

The potential ecological effects on the SPA are of 4 types:

1. Type 1: Direct disturbance of any bird activities
2. Type 2: Competition between birds and mussel producers for a common resource
3. Type 3: Direct impacts of fishery/production activities on habitats of importance to birds
4. Type 4: Indirect impact on waterbirds such as increased competition between individuals leading to reduced population viability

Table 3. Indicative effects of shellfish production on the qualifying interests and conservation interests of Castlemaine Harbour.

Potential Effect	Potential Sources
1. Smothering causing a change in the biological composition and/or availability of prey items	Placement of mussel seed Settlement of mussel larvae in high densities
2. Noise / visual disturbance causing displacement of species	Use of vessels Use of vehicles on shore
3. Changes in turbidity/ sediments causing a change in the biological composition and/or availability of prey items	Placement of mussel seed Dredging of mussels Baffling effect of structures on shore.
4. Changes in oxygen levels causing a change in the biological composition and/or availability of prey items	Placement of mussel seed Increased organic loading on seabed beneath oyster trestles
5. Introduction of non-native species causing a change in the biological composition and/or availability of prey items	Cultivation of *Crassostrea gigas*
6. Abrasion/Physical disturbance/Compaction causing a change in the biological composition and/or availability of prey items	Dredging of mussels Use of vehicles on shore
	Foot traffic on shore
7. Displacement or relocation of species	Dredging of mussels Dredging of clams
8. Selective extraction of target species causing a change in the biological composition and/or availability of prey items	Dredging of mussels Potting crab
9. Selective extraction of non-target species causing a change in the biological composition and/or availability of prey items	Dredging of mussels Potting crab

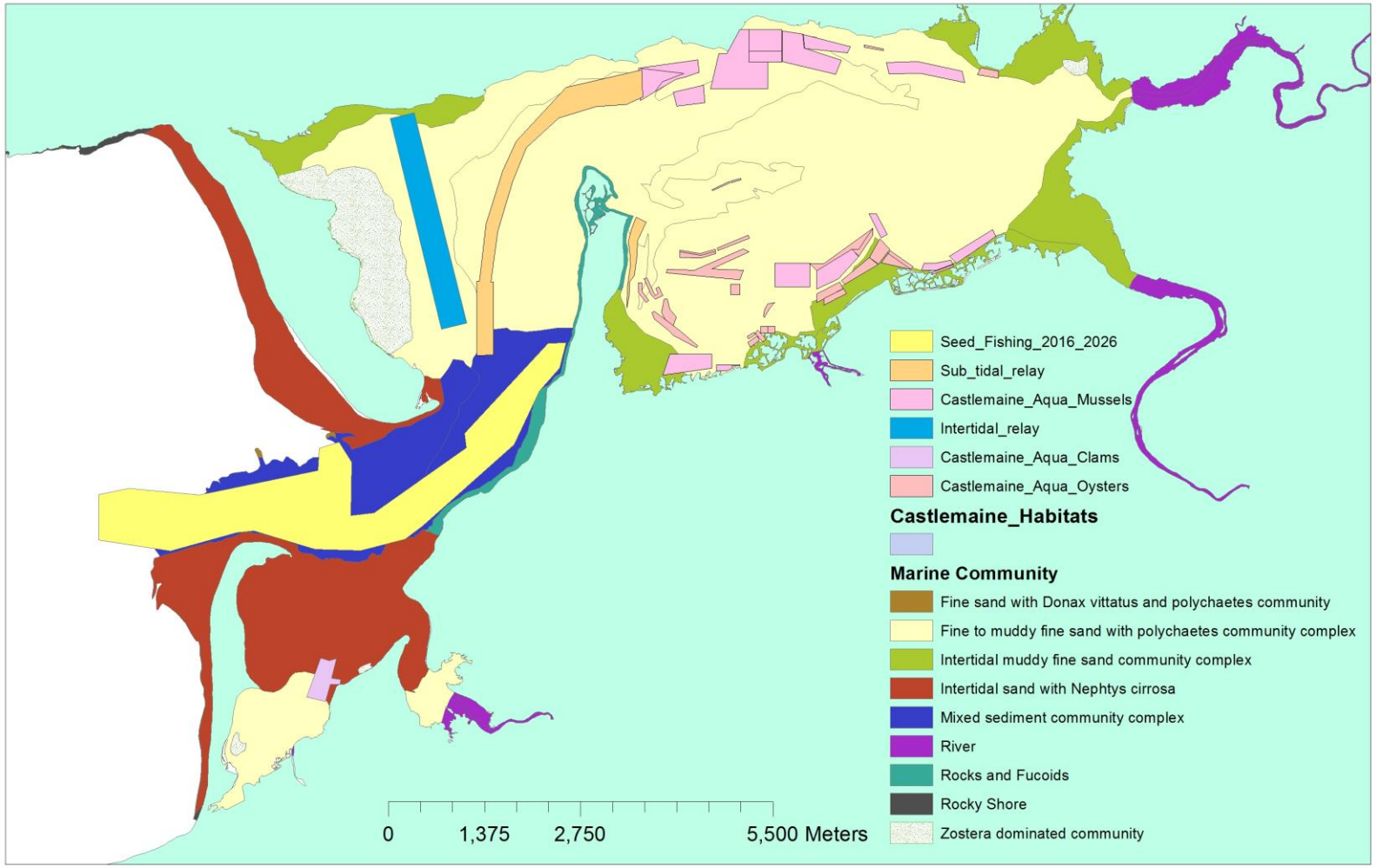

Figure 5. Shellfish production activities in Castlemaine Harbour in relation to distribution of marine habitats.

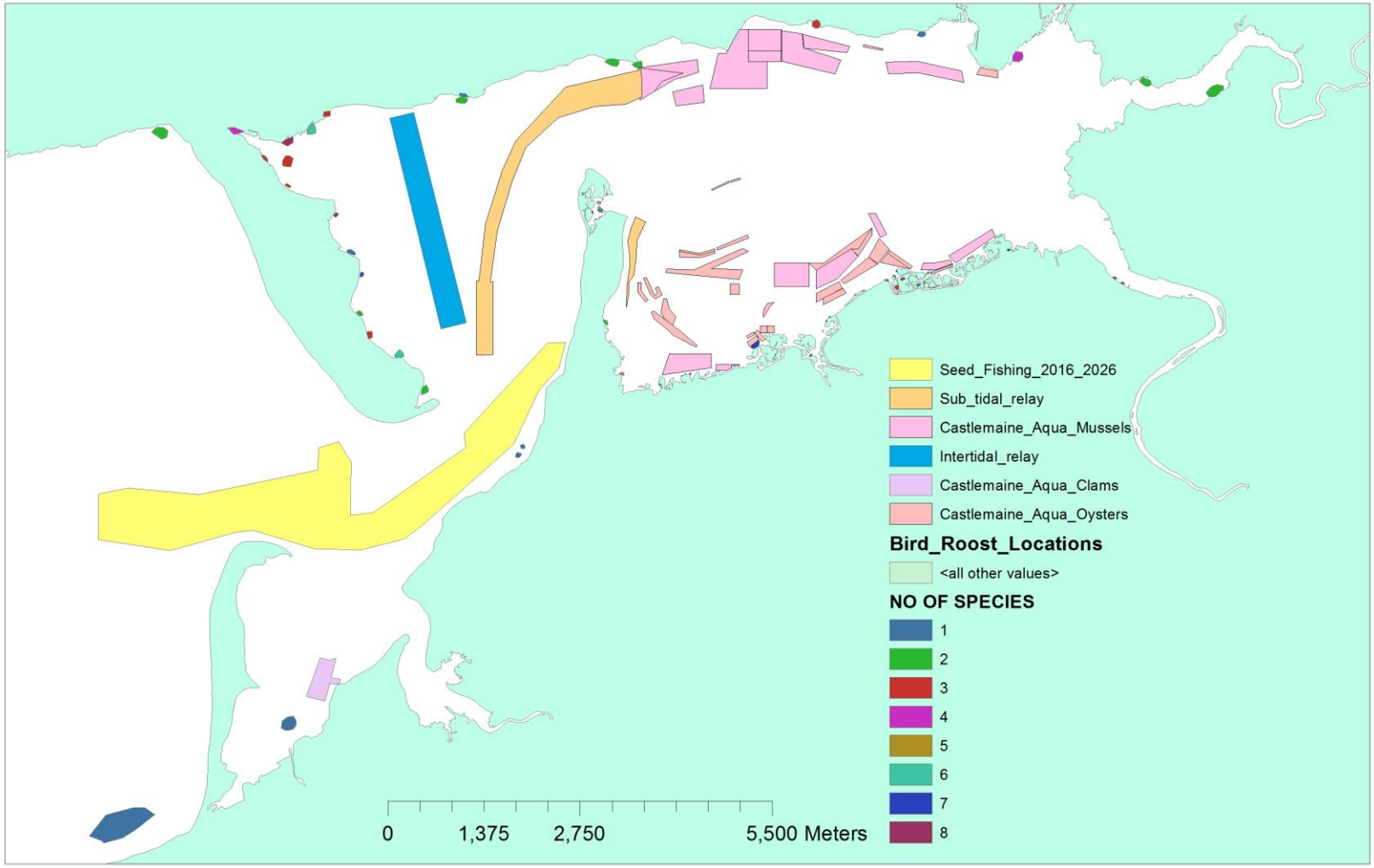

Figure 6. Shellfish production activities in Castlemaine Harbour in relation to bird roost locations. The number of species using the roost is indicated

Section 5 - Appropriate Assessment Screening

If the proposed activity overlaps spatially with or can indirectly affect designated marine habitats or species at the site then appropriate assessment of the potential impact of the activity on the conservation objectives for the qualifying interest is warranted. If there is no spatial overlap or no possibility of indirect impacts no impact is deemed possible and further assessment is not necessary (Table 4).

Table 4. Potential overlap of activities and qualifying interests at Castlemaine Harbour SAC and SPA. SCI = species of special conservation interest (designated species)

All Qualifying Interests	Annex qualifying interest	Is further assessment required?	Justification
Petalophyllum ralfsii (Petalwort)	Annex II	No	No spatial overlap
Salmo salar (Atlantic Salmon)	Annex II	**Yes**	Further assessment required
Petromyzon marinus (Sea Lamprey)	Annex II	**Yes**	Further assessment required
Lampetra fluviatilis (River Lamprey)	Annex II	**Yes**	Further assessment required
Lutra lutra (Otter)	Annex II, IV	**Yes**	Further assessment required
Fixed coastal dunes with herbaceous vegetation (grey dunes)	Annex I	No	No spatial overlap
Mediterranean salt meadows (*Juncetalia maritimi*)	Annex I	No	No spatial overlap
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Annex I	No	No spatial overlap
Dunes with *Salix repens ssp.argentea (Salix arenariae*)	Annex I	No	No spatial overlap
Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)	Annex I	No	No spatial overlap
Embryonic shifting dunes	Annex I	No	No spatial overlap
Annual vegetation of drift lines	Annex I	No	No spatial overlap

All Qualifying Interests	Annex qualifying interest	Is further assessment required?	Justification
Spartina swards (*Spartinion maritimae*)	Annex I	No	No spatial overlap
Estuaries	Annex I	**Yes**	Further assessment required
Perennial vegetation of stony banks	Annex I	No	No spatial overlap
Salicornia and other annuals colonizing mud and sand	Annex I	No	No spatial overlap
Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae*)	Annex I	No	No spatial overlap
Humid dune slacks	Annex I	No	No spatial overlap
Mudflats and sandflats not covered by seawater at low tide	Annex I	**Yes**	Spatial overlap/effects possible further assessment required
Red-throated Diver	SCI in SPA	**Yes**	Further assessment required
Cormorant	SCI in SPA	**Yes**	Further assessment required
Light-bellied Brent Goose	SCI in SPA	**Yes**	Further assessment required
Wigeon	SCI in SPA	**Yes**	Further assessment required
Mallard	SCI in SPA	**Yes**	Further assessment required
Pintail	SCI in SPA	**Yes**	Further assessment required
Scaup	SCI in SPA	**Yes**	Further assessment required
Common Scoter	SCI in SPA	**Yes**	Further assessment required
Oystercatcher	SCI in SPA	**Yes**	Further assessment required
Ringed Plover	SCI in SPA	**Yes**	Further assessment

All Qualifying Interests	Annex qualifying interest	Is further assessment required?	Justification
			required
Sanderling	SCI in SPA	**Yes**	Further assessment required
Bar-tailed Godwit	SCI in SPA	**Yes**	Further assessment required
Redshank	SCI in SPA	**Yes**	Further assessment required
Greenshank	SCI in SPA	**Yes**	Further assessment required
Turnstone	SCI in SPA	**Yes**	Further assessment required
Chough	SCI in SPA	No	No spatial overlap
The wetland habitat and the waterbirds that rely on it	79/409/EEC Wetland & Waterbirds protection	**Yes**	Further assessment required

Section 6 - Appropriate Assessment: Special Area of Conservation

1. Assessment of the effects of mussel production and in combination effects on the Conservation Objectives for marine communities

Appropriate Assessment Screening (Section 5) of mussel and other aquaculture activities failed to exclude the possibility of significant impacts to a number of qualifying interests because these activities spatially overlap with the distribution of the qualifying interests concerned. Such activities are subject to appropriate assessment below on the basis that they overlap the qualifying interest and the Natura impact statement identified pathways for potential ecological effects.

2. Methods for Appropriate Assessment

Determining significance

The significance of the possible effects of the proposed activities on habitats, as outlined in the Natura Impact statement, is determined here in the appropriate assessment. The significance of effects is determined in relation to the Conservation Objective guidance for constituent habitats (NPWS 2011a) (Figure 7).

1. The degree to which the activity will disturb the qualifying interest. By disturb is meant change in the characterising species, as listed in the Conservation Objective guidance (NPWS 2011a) for constituent habitats.
2. The persistence of the disturbance in relation to the resilience of the habitat and which determines the duration of time for which the disturbance might last
3. The area of habitats or proportion of populations disturbed. In the case of habitats disturbance of less than 15% of the habitat area is deemed to be insignificant.

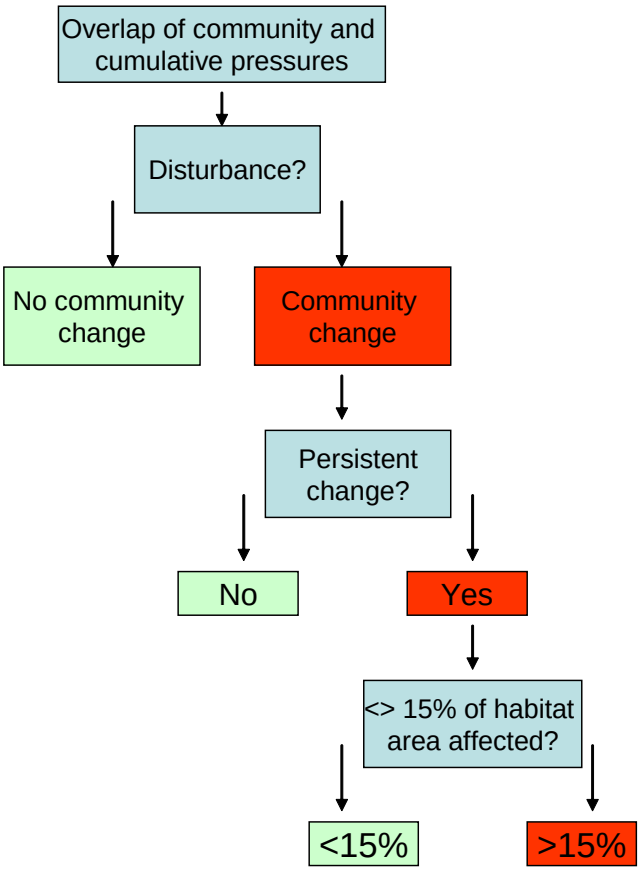

Figure 7. Determination of significant effects on community distribution, structure and function (interpreted from NPWS 2011a).

Effects will be deemed to be significant when cumulatively they lead to long term change in communities in greater than 15% of the area of any constituent community listed in Table 2.

3. Assessment of sub-tidal fishing for seed mussel

Natura Impact Statement for this activity

Fishing for seed mussel in the sub-tidal waters of inner Dingle Bay reduces the extent and biomass of the seed mussel bed and may change the biota in the area (Table 3).

Assessment

- The proposed seed mussel fishery occurs on the sub-tidal mixed sediment community complex in Estuary habitat.
- The area of potential overlap of the proposed mussel seed fishery and the mixed sediment community complex is 455/802ha or 56%. The overlap in any given year will be less than this; in any given year the seed bed may develop in a proportion of this area and in a different location (Figure 8, Table 5).

Table 5. Area of mussel seed bed and % of the mixed sediment community occupied by mussel seed in each year 2009-2015. Seed bed boundaries from BIM seed mussel surveys.

Year	Seed area (ha)	%overlap with mixed sediments
2009	32	3.99
2010	44	5.49
2011	26	3.24
2012	31	3.87
2013	101	12.59
2014	76	9.48
2015	128	15.96

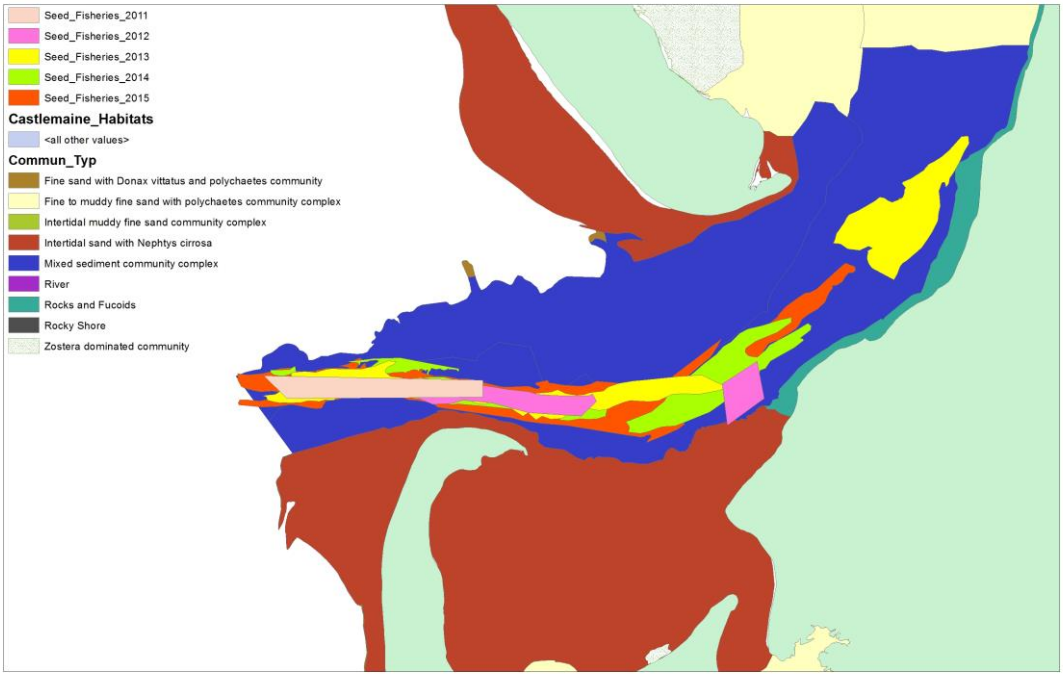

Figure 8. Annual location of seed mussel beds (2011-2015) in mixed sediment community (blue) at the entrance to Castlemaine Harbour. Seed bed boundaries from BIM seed mussel surveys.

- The annual exploitation of the seed mussel constitutes habitat disturbance as a principal characterising species (mussel) is the target species and its biomass is substantially reduced by fishing.
- Seed mussel beds in this area are ephemeral and unstable. The mussel bed and underlying sediment is prone to turn over and wash out by winter storms and by starfish predation. This is a general, although not universal, characteristic of seed mussel beds throughout Europe (Dare *et al*. 2004). In Castlemaine, seed mussel beds occur in different locations each year on sand, mud, shingle and stones and show no distinct substrate preference. Removal of seed mussel by dredging therefore occurs against a background of dynamic natural change that occurs on an annual basis in this habitat. It is considered that likely effects on the resident biological communities that might arise through smothering or changes in suspended sediment loading will not be significant against the natural dynamics of the site. Recoverability of all biotopes associated with seed mussel, following physical disturbance, is high (www.marlin.ac.uk). The substratum required for settlement of mussel and re-establishment of the mussel bed is unlikely to be significantly altered above background levels by fishing in these dynamic high energy habitats. The types of dredge used for dredging mussel seed beds are lighter than other bivalve dredges and do not have teeth. At the time of fishing, the mussel beds are elevated from the surrounding substratum, the dredge does not

penetrate the seafloor and disturbance of the sediments below the bed is not therefore significant, again compared to natural background variability.

- This is supported by evidence of repeated annual settlement of mussels in the area even though commercial seed fishing has been in operation since 1977 and also the data from BIM seed surveys 2009-2015 (Table 5) which shows increased areas of seed settlement in 2013-2015 compared to 2009-2012 and therefore that the fishery is not affecting the suitability of the mixed sediment habitat for seed settlement.
- The appropriate assessment of the seed fishery is summarised in Table 6.

Conclusion

- Less than 15% of any individual community type is likely to be affected in any one year by the fishery
- The activity does not represent persistent disturbance as it occurs for a very limited number of days per year
- The activity is not significantly disturbing over and above the natural dynamics of seed mussel beds and sediments in the area and the mixed sediment community continues to support annual settlement of mussel seed

Mitigation

The activity can be allowed. No mitigation actions are proposed.

Table 6. Concluding Appropriate Assessment in relation to sub-tidal fishing for seed mussel.

Activity	**Relevant ecological effects (from statement of AA)**	**Habitat affected**	**Community affected within habitat**	**Attribute**	**Attribute following proposed activity**	**Significance of impact**	**Rationale**	**Supporting evidence**	**Confidence**
Sub-tidal fishing for seed mussel	Reduction of mussel bed, leads to change in structure and functioning of the benthic community	Estuary	Mixed sediment community complex	Habitat area	Stable (<15% affected)	Not significantly disturbed	Less than 15% of any constituent community is disturbed in any year.	GIS data, evidence from previous years fisheries at the site	High
				Community distribution	Stable (<15% affected)	Not significantly disturbed			High

4. Assessment of relaying of seed mussel on the inter-tidal sand flat (intertidal relay area and licensed mussel areas)

Natura Impact Statement for this activity

The relaying of seed mussel on the intertidal sand flat leads to change in the existing biota and sediment (Table 3).

Assessment

Intertidal relay area:

- The area occupied by the proposed relay activity in the intertidal relay area, excluding intertidal mussel aquaculture sites, is 111ha.
- The area overlaps with;
    - The intertidal muddy fine sand community complex by 0.36% (2/554ha)
    - Fine to muddy fine sand community complex by 4.4% (111/2486ha)
- Not all of the habitat within the intertidal relay area is covered in mussels following relay (Figure 9, Figure 10, Figure 11)
- Typically the mussel cover is extremely patchy (and difficult to estimate using ground survey
- Aerial imagery collected during 2013, 2014 and 2015 shows relatively sparse cover in the north of the area and somewhat higher coverage in the south. Typically mussel cover is less than 12% overall and is usually less than 5% in the north of the area.
- Mussel relay also extends east of the nursery area to the low water mark. This expanded relay area is alluded to in the fishery natura plan 2016-2026.
- Based on monitoring of the 2011-2015 plan mussel cover of intertidal habitats, resulting from the annual implementation of the proposed fishing plan, is therefore expected to result in mussel cover of 5-12% of the intertidal relay area anywhere within the fishery order rather than in the 111ha outlined in the 2016-2026 fishery natura plan (Annex I).

Intertidal mussel aquaculture sites:

- The area occupied by licenced mussel aquaculture sites is 223ha. Of this 118ha is intertidal.
- Intertidal mussel aquaculture sites overlaps with;
    - The intertidal muddy fine sand community complex by 1.8% (10/554ha)
    - Fine to muddy fine sand community complex by 4.7% (118/2486ha)
- Cumulatively (relay in the nursery area and relay in intertidal portions of the mussel aquaculture sites) intertidal mussel production overlaps with;
    - The intertidal muddy fine sand community complex by 2.2%

  - Fine to muddy fine sand community complex by 9.1%
- Presuming that relay operations in intertidal mussel aquaculture sites are similar to that practised in the intertidal relay area in the fishery order then 5-12% of these sites could be covered in seed mussel.
- Pressure on habitats is therefore 5-12% of the 2.2% and 9.1% of affected habitats.
- Given the nature of the impact outlined in Table 3, the activity of relaying seed mussels onto intertidal habitats could constitute a disturbance by virtue of the fact that the activity will likely lead to a shift in community composition. However, the data provided in Annex II suggests that the species composition of benthic macrofauna in sand and in sand/mud under mussel cover in the intertidal mussel nursery area in Castlemaine Harbour is largely similar i.e.
- Benthic core samples taken in the nursery area in April 2010 (see Annex II) shows that the benthic fauna in the nursery area is low in abundance and diversity. This is not unexpected in this brackish water area. Mussel cover has a significant effect on the abundance and species composition of polychaetes living in the sand underneath the mussel bed but not on bivalves or crustaceans. The abundance of a number of deposit feeding polychaetes is reduced under mussel and the abundance of other deposit feeding polychaetes is higher.
- The limited change in species composition in areas covered by seed mussel and not may relate to the temporary nature of the cover; the seed is removed a few months later and the infauna may revert to pre-disturbed condition.
- Given that the change in species composition is limited, that the disturbance is not persistent, that the percentage overlap of intertidal relays and habitats is generally less than 15% and that less than 10% of habitat within this 15% is directly affected intertidal relay of mussels onto these habitats relative to the conservation objectives is not significant.

Habitat potentially affected indirectly:

Sea grass:

- The intertidal seagrass bed east of Inch could be indirectly affected by mussel relay to the east if seed mussel or mussel mud drifts onto the seagrass and become established. This would reduce the area of seagrass habitat
- The distribution of the seagrass bed is mapped annually by the Environmental Protection Agency (EPA) and the eastern boundary has been mapped by MI in some years.
- The distribution and area of seagrass has been stable since 2006 (EPA pers com). The area however is less than that indicated in the NPWS habitat map (Figure 12). EPA

distribution maps indicate an area of 160-175ha compared to NPWS estimates of 221ha. The difference is mainly accounted for on the western edge. The eastern edge, closest to the mussel relay areas, is stable in location and extent.

- The intertidal mussel relaying site is approximately 300m distant (summary statistics of 12 measurements of this distance indicate a mean of 290m, standard deviation of 61m and a minimum distance of 202m from the eastern edge of the sea grass bed. Although the footprint of the mussel relaying activity is larger than the allotted nursery area, this is mainly seaward of the nursery area rather than towards the seagrass bed. There is no risk of direct impact i.e. active relaying of seed or active dredging close to or through the sea grass bed will not occur. Aerial monitoring data and EPA observations show there has not been any significant encroachment of mussels onto the seagrass bed between 2011-2015.
- The appropriate assessment of intertidal relay of mussels is summarised in Table 8.

Recommendation

The activity may be permitted on the basis there is a high confidence that there will be no significant impact on seagrass habitats.

Mitigation

No mitigation actions are proposed.

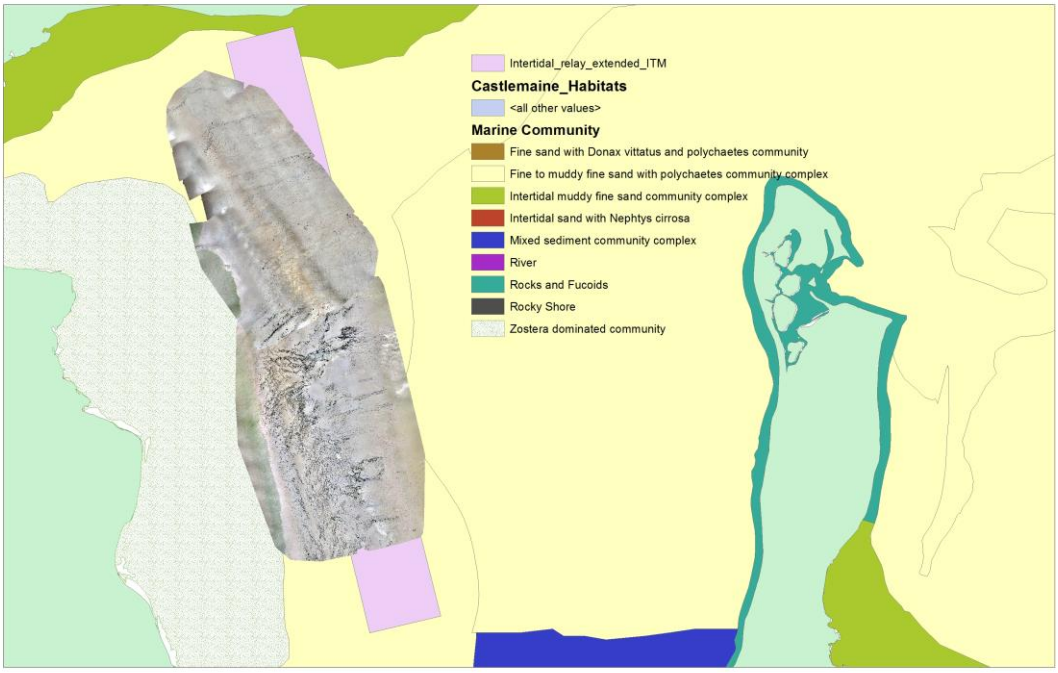

Figure 9. Aerial imagery of habitat with sparse and patchy mussel cover over the intertidal relay area in 2014. Mussels are black dots. The edge of the seagrass bed is visible in the image and maps accurately onto the habitat map.

Figure 10. Aerial imagery of habitat with sparse and patchy mussel cover over the intertidal relay area and east of the area in 2015. Mussels are black dots. Mussel distribution patterns are due to the process of relaying the mussels from a vessel moving in circles

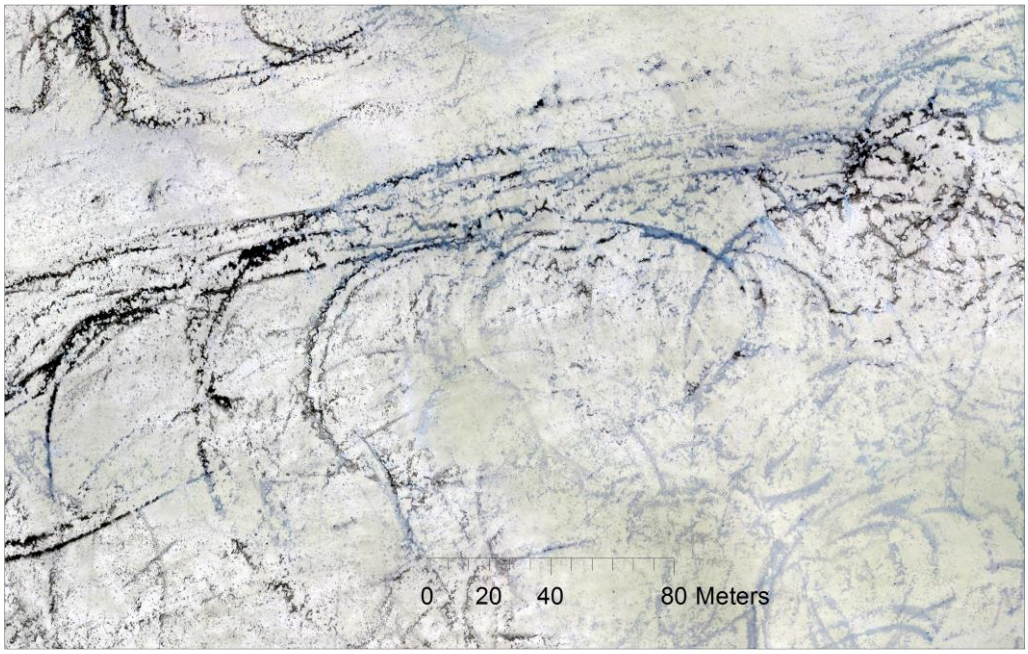

Figure 11. Zoomed (+) aerial imagery of mussel relay patterns in a section of the north of the relay area in 2015. Note scale bar. Out of focus mussel patches are underwater.

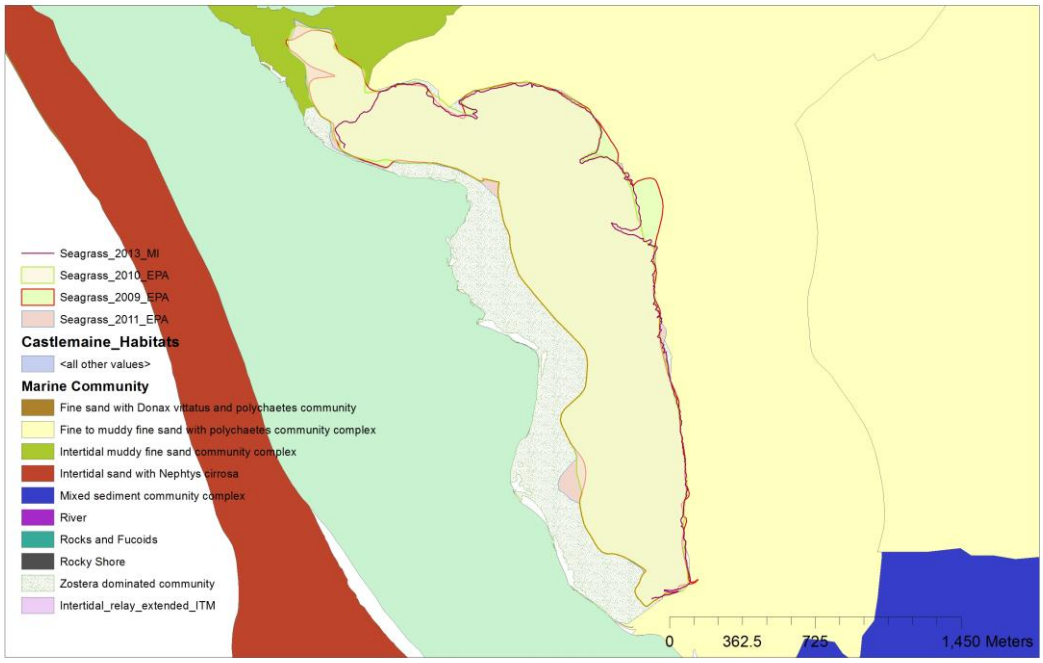

Figure 12. Distribution of seagrass in Castlemaine Harbour as determined by NPWS marine community maps and EPA annual surveys.

Table 7. Concluding Appropriate Assessment in relation relaying of seed mussel on the intertidal sand flat.

Activity	Relevant ecological effects (from statement of AA)	Habitat affected	Community affected within habitat	Attribute	FCS following proposed activity	Significance of impact	Rationale	Supporting evidence	Confidence
Relaying of seed mussel on the intertidal sand flat	The existing benthic invertebrate fauna will change	1140/1130	Fine to muddy sand with polychaetes community complex; intertidal muddy fines sand community complex. Seagrass (indirectly)	Habitat area	Stable	Minor	The % overlap of activity and any benthic Community is below 15%. The effects are not disturbing to the existing community	GIS, benthic data from the site in 2010, aerial monitoring periodically between 2011-2015, EPA survey data	High
				Community distribution	Stable	Minor			High
				Area occupied by seagrass on sand	Stable	None			High

5. Assessment of dredging of half-grown mussel from the inter-tidal area

Natura Impact Statement for this activity

Dredging of mussels from the intertidal sand flat leads to changes in the sediment and benthic communities in this area (Table 3).

Assessment

Intertidal relay area (within Fishery Order):

- The area occupied by the proposed dredging activity in the intertidal relay area excluding intertidal mussel aquaculture sites is 113ha.
- The area overlaps with;
    - The intertidal muddy fine sand community complex by 0.36% (2/554ha)
    - Fine to muddy fine sand community complex by 4.4% (111/2486ha)
- Not all of the habitat within the intertidal relay area is covered in mussels following relay (Figure 8,Figure 9,Figure 10) as described above for Activity 2. Typically it ranges from 5-12%.

Intertidal mussel aquaculture sites:

- The area occupied by licenced mussel aquaculture sites is 223ha. Of this 118ha is intertidal.
- Intertidal mussel aquaculture sites overlaps with;
    - The intertidal muddy fine sand community complex by 1.8% (10/554ha)
    - Fine to muddy fine sand community complex by 4.7% (118/2486ha)

- The cumulative area of habitat affected directly by Activity 3 is
    - The intertidal muddy fine sand community complex by 2.2%
    - Fine to muddy fine sand community complex by 9.1% (118/2486ha)

- The relaying of seed in the inter-tidal area leads to some changes in the species composition of macrobenthos. The removal of mussel cover by dredging will, presumably, lead to a reversal of those changes and a return to a species composition representative of the community type. The dredge essentially removes the mussel structure and the fauna associated with it. The underlying sediment may remain undisturbed as the 'mussel mud', which accumulates in the bed, detaches the bed from the underlying substrate (Saurel *et al*. 2003). The typical fauna of this underlying substrate is then re-established at a rate depending on the sediment type and exposure. Dredging releases fine sediment, from the mussel mud, into the water

column and the dispersal plume depends on local tidal conditions during dredging. In areas where mussels are bottom cultivated disturbance and dispersal of the mussel mud is important in facilitating the recovery of the typical fauna of the underlying sediment and to avoid raising the bed higher into the inter-tidal zone.

- The distribution of seagrass and in particular its eastern edge closest to mussel production activities has been shown to be stable from 2011-2015 and since 2006 when EPA surveys were initiated. Potential effects of dispersal of fine sediments onto the seagrass bed resulting from dredging activity do not therefore appear to occur in this location. Dredging activity, therefore, proposed in the 2016-2026 fishery natura plan, is not expected to have any direct or indirect significant effect on seagrass.
- The appropriate assessment of dredging of mussel from intertidal habitat is summarised in Table 8.

Conclusion

The activity may be permitted on the basis there is a high confidence that there will be no significant impact on the habitat.

Mitigation

No mitigation actions are proposed.

Table 8. Concluding Appropriate Assessment in relation to Activity 3 (Dredging of seed mussel from the intertidal sand flats).

Activity	**Relevant ecological effects (from statement of AA)**	**Habitat affected**	**Community affected within habitat**	**FCS Parameter**	**FCS following proposed activity**	**Significance of impact**	**Rationale**	**Supporting evidence**	**Confidence**
Dredging of seed mussel from the intertidal sand flat	Dredging effectively removes the mussel bed from the area thereby changing the existing biota in the dredged area Dredging can potentially displace fine materials onto sensitive *Zostera* communities west of the nursery area	1140/1130	Fine to muddy sand with polychaetes community complex; intertidal muddy fines sand community complex	Habitat area	Stable	Minor and temporary	The % overlap of activity with any benthic Community is less than 15%. The activity potentially reverses any impacts that might occur due to Activity 2.	GIS, Benthic data, EPA surveys, MI surveys.	High
				Community distribution	Stable	Minor and temporary			High
				Area occupied by seagrass on sand	Stable	None			High

6. Assessment of relaying and dredging of mussels in the sub-tidal channel of Castlemaine Harbour

Natura Impact Statement for this activity

Relaying and dredging of mussels in the sub-tidal channel of Castlemaine Harbour leads to changes in the sediments and benthic communities in the area (Table 3).

Assessment

Sub-tidal relay area (within Fishery Order):

- The area occupied by the proposed relay activity in the sub-tidal relay area, excluding sub-tidal mussel aquaculture sites, is 136ha.
- The area overlaps with;
    - Mixed sediments 0.74% (6/802ha)
    - Fine to muddy fine sand with polychaetes community complex 12% (130/1069ha)

Sub-tidal portions of mussel aquaculture sites:

- The area occupied by licenced mussel aquaculture sites is 223ha. Of this 93ha is sub-tidal.
- Subtidal mussel aquaculture sites overlaps with fine to muddy fine sand community complex by 8.6% (93/1069ha)
- The cumulative overlap of the sub-tidal fine to muddy fine sand and Activity 4 is 20.6%
- Although no survey of mussel cover was undertaken in the channel the sub-tidal faunal survey completed in the channel in autumn 2009 indicates that mussel cover is relatively low (see Annex III).
- Although the fauna in this estuarine channel is, as expected, low in diversity and abundance the diversity and abundance of macrobenthos recorded was significantly higher in samples containing mussels than in other areas (Annex III). It is not clear if this is due to the presence of mussels or is simply a spatial effect. Mussels, however, provide additional structural habitat for colonisation of macrofauna.
- The 2009 sub-tidal survey (Annex III) shows that the fauna is dominated by polychaetes and that the sediments are mainly fine to medium sands with varying proportions of shell. Mussel cover appears to be low.
- Although the activity may overlap with 20.6% of the muddy fine sand community complex only a proportion of this area is directly affected. The activity appears to be non-disturbing given the data from the sub-tidal faunal survey in 2009.
- The appropriate assessment of relaying and dredging mussels from sub-tidal habitats is summarised in Table 9.

Conclusion

The activity may be permitted on the basis there is a high confidence that there will be no significant impact on the habitat.

Mitigation

No mitigation measures are proposed.

Table 9. Concluding Appropriate Assessment in relation to relaying and dredging of mussel in the sub-tidal channel of Castlemaine Harbour).

Activity	**Relevant ecological effects (from statement of AA)**	**Habitat affected**	**Community affected within habitat**	**FCS Parameter**	**FCS following proposed activity**	**Significance of impact**	**Rationale**	**Supporting evidence**	**Confidence**
Relaying and dredging of mussel in the sub-tidal channel of Castlemaine Harbour	Relaying can smother existing fauna leading to change in community structure and function. Dredging effectively removes the mussel bed from the sub-tidal, disturbs sediments and leads to changes in fauna	1130	Fine to muddy sand with polychaetes community complex	Habitat area	Stable	Minor	The % overlap of activity with sub-tidal fine to muddy fine sand is 20% but only a proportion of this 20% is directly relayed with mussel.	GIS, Benthic data 2009.	High
				Community distribution	Stable	Minor			High

7. Assessment of activities in combination with mussel production

Oyster production

- Licenced trestle production of oysters (*Crassostrea gigas*) occurs on 81ha.
- Most of this activity occurs on intertidal fine to muddy fine sand habitat and to a lesser extent on intertidal muddy fine sand
- Oyster production on trestles does not have significant impacts on sedimentary habitats at the scale of operation in Castlemaine (Forde *et al*. 2015). Although sediment compaction can result from persistent use of vehicles on access routes this is not relevant to Castlemaine where oyster trestles are accessed via boats.
- Pacific oyster have become naturalised in some locations in Ireland (Kochmann *et al* 2012). This would lead to changes in habitats. The use of triploid (non-reproducing) stock is the main method employed to manage this risk. There is no evidence of naturalisation of Pacific oysters in Castlemaine. Naturalisation is more likely to occur in areas where water residence times are over 21 days (Kochmann *et al* 2013). Residence times in Castlemaine are less than 15 days.
- The introduction of non-native species as 'hitchhikers' on and among culture stock is also considered a risk, the extent of which is dependent upon the duration the stock has spent 'in the wild' outside of the site of interest. Half-grown stock (15 - 30g oysters) which would have been grown for extended periods in places (in particular outside of Ireland) present a higher risk. Oysters grown in other bays in Ireland and 'finished' in the site of interest, would not appear to present a risk of introduction of non-native species assuming best practice is applied (e.g. http://invasivespeciesireland.com/cops/aquaculture/). This is the case in Castlemaine.

Clam production

- Licenced production of clams (*Ruditapes philippinarum*) occurs on 16ha of intertidal habitat on the south west of the SAC.
- Clam production occurs on intertidal sand with *Nephthys cirrosa* (<1% of habitat) and on fine to muddy fine sand with polychaetes community (<1% of habitat)
- No production has occurred in recent years
- Given the scale of the activity the effects on intertidal sand habitat is not significant

Cockle gathering

- One shellfish gatherer collects cockles using a cockle rake weekly in the intertidal fine to muddy fine sand habitat north east of the clam production site. The area over which this activity occurs may be over 20ha in extent but the scale and intensity of the activity

is limited.

- Given the scale of the activity it is not likely to have significant impacts on intertidal habitats. Studies on the impact of suction dredging for cockles in Dundalk Bay failed to find significant cumulative effects on habitats. Hand gathering is much less disturbing to sediments than is suction dredging.

Predator control, winkle picking, discharges

- The predator control programme seeks to reduce the populations of shore crab which predate on seed mussel. Shore crab populations are productive and the capacity to control the population using the scale of control described in the management plan is limited. The control relies on behavioural attraction of the crabs to baited pots. The fishing technique is highly selective and benign on non-target fauna and on the physical environment. The creation of a seed mussel bed on the inter-tidal area is likely to increase the productivity of mobile epifauna such as shore crab through provision of refuges for postlarvae and juvenile crab and a food source for crab. The predator control balances this by removing a proportion of the crab biomass.
- Periwinkles (*Littorina littorea*) are picked in the intertidal area by an unknown number of operators. Periwinkle is not a typical species of intertidal sand and mud flats. The significance of this activity in relation to habitat area, structure and function is deemed to be insignificant.
- Waste water treatment from urban centres surrounding Castlemaine Harbour have improved since the 2011 assessment.
- The appropriate assessment of Activity 7 is summarised in Table 10.

Conclusion

The activities will not have significant in combination effects with mussel production.

Mitigation

No mitigation actions are proposed.

Table 10. Concluding Appropriate Assessment in relation to activities in combination with mussel production.

Activity	Relevant ecological effects (from statement of AA)	Habitat affected	Community affected within habitat	FCS Parameter	FCS following proposed activity	Significance of impact	Rationale	Supporting evidence	Confidence
In combination, producing oysters, picking of periwinkles and predator control and discharges	Predator control, other fish removals and discharges may alter the species composition at the site and the structure and functioning of communities	1140/1130	*Various*	Habitat area	Stable	Minor	These activities have local effects and do not significantly alter the range or area of the benthic community	Expert judgement and inference from other studies. Oyster benthic impact study	Moderate
				Habitat structure and function	Stable	Minor			Moderate

8. Assessment of the effects of shellfish production and in combination effects on the Conservation Objectives for Otter, Salmon and Lamprey

Statement for AA

As the shellfish production activities within the SAC spatially overlap with Otter (*Lutra lutra*), Salmon (*Salmo salar*) and Lamprey these activities may have negative effects on the abundance and distribution of populations of these species.

*Otter (*Lutra lutra*)*

- The proposed activity will not lead to any modification of the following attributes for otter
  - Extent of terrestrial habitat,
  - Extent of marine habitat or
  - Extent of freshwater habitat.
  - The activity involves net input rather than extraction of fish biomass so that no negative impact on the essential food base (fish biomass) is expected

- The number of couching sites and holts or, therefore, the distribution, will not be directly affected by mussel production activity
- National surveys of otter in Ireland in 2006 found that 75% of sites surveyed in the south west of Ireland showed signs of otter occupancy. There are no specific data on otter population size in Castlemaine although they are present throughout the area.
- Shellfish production activities are unlikely to pose any risk to otter populations through entrapment or direct physical injury.
- Disturbance associated with vessel and foot traffic could potentially affect the distribution of otters at the site. However, as shown below for bird populations, the level of disturbance is likely to be very low.
- The crab control programme associated with the inter-tidal mussel area uses baited pots that could attract otters. The risk of entrapment is low because of the specific design of the crab gear which uses small hard-eye rather than soft-eye entrances. The latter could pose more risk to otters that may try and enter the pot through the eye.

*Salmon (*Salmo salar*)*

- Salmon populations run into the Rivers Laune and Maine which flow into Castlemaine Harbour.
- Shellfish production activities do not pose any risk to the following salmon attributes
  - Distribution (in freshwater)
  - Fry abundance (freshwater)

- Population size of spawners (fish will not be impeded or captured by the proposed activity)
- Smolt abundance (out migrating smolts will not be impeded or captured by the proposed activity)
- Water quality (freshwater)

*Sea Lamprey (*Petromyzon marinus*) and River Lamprey (*Lampetra fluviatilis*)*

- There are no specific data on populations of Sea Lamprey or River Lamprey in Castlemaine
- The proposed activity will not have any effect on sea lamprey and river lamprey attributes
  - Extent of anadromy (% of river accessible)
  - Access to spawning (freshwater)
  - Availability of juvenile habitat (freshwater 3rd order channels)
  - Spawning beds (freshwater)
  - Juvenile density (freshwater
  - Population structure of juveniles (freshwater)
  - Extent of spawning bed habitat (freshwater)
- The appropriate assessment in relation to effects on otter, salmon and lamprey is summarised in Table 11.

Conclusion

The activities will not have significant effects on otter, salmon or lamprey.

Mitigation

No mitigation actions are proposed.

Table 11. Concluding Appropriate Assessment in relation to effects of all activities on salmon, otter and lamprey.

Activity	**Relevant ecological effects (from statement of AA)**	**Species affected**	**Attributes**	**Attribute following proposed activity**	**Significance of impact**	**Rationale**	**Supporting evidence**	**Confidence**
All activities	Activities may affect the abundance and distribution of the species concerned	Salmon, Otter, Lamprey	All	No change	None	No spatial overlap with attributes or no direct or indirect impact envisaged	GIS, Life cycle, Behaviour	High

Section 7 - Appropriate Assessment: Special Protection Area

1. Assessment of the effects of fisheries and aquaculture production on waterbirds in the SPA

Introduction

- This section supports the Appropriate Assessment of the potential impacts of mussel production activities proposed in the 2016-2026 mussel fishery natura plan (Annex I), mussel production in licenced aquaculture sites and oyster and clam production and other human activities on the conservation status of waterbird populations of special conservation interest in the Castlemaine Harbour SPA (site code 004029).

- One bird species (Chough), listed as a species of special conservation interest, is not included in this assessment because the screening assessment concluded that there is not any spatial overlap between the activities being assessed and the distribution of this species.

Conservation Objective 1

- Conservation Objective 1 for the Castlemaine Harbour Special Protection Area is defined as follows: -

- *To maintain the favourable conservation condition of the waterbirds listed for Castlemaine Harbour SPA. This objective is defined by the following attributes and targets (NPWS 2011b):-*

    - *To be favourable, the long term population trend for each waterbird species should be stable or increasing, indicating that the populations are maintaining themselves. Waterbird populations are deemed to be unfavourable when they have declined by 25% or more, as assessed by the most recent population trend analysis.* [Attribute 1]

    - *To be favourable, there should be no significant decrease in the numbers or range (distribution) of areas used by the waterbird species, other than that occurring from natural patterns of variation.* [Attribute 2]

Data sources

- The spatial extent of proposed mussel seed fishing and relay activities as described in Annex I (Seed mussel Fishery Natura Plan)
- The spatial extent of licenced mussel, oyster and clam production activities as of February 2016 (source:DAFM)
- The waterbird data sources used for the assessment are as follows:

    - Irish Wetland Bird Survey counts 1994/95-2014/15
    - NPWS Baseline Waterbird Survey 2009/10 counts
    - Transect counts of the mussel nursery area in February-March 2010 (see Annex V: Gittings and O'Donoghue, 2011a).
    - Counts of the Douglas Strand-Cromane area in January-February 2011 (see Annex VII: Gittings and O'Donoghue, 2011b).
    - Counts of the Rossbehy Creek area in January-March 2011 (see Annex V: Gittings and O'Donoghue, 2011a).

Assessment methodology

There are very few published studies on the effects of intertidal mussel, oyster and clam aquaculture on waterbirds. Those that are available cover few of the species of Special Conservation Interest at Castlemaine Harbour and, in the case of clams and oysters, are not directly relevant to the situation at Castlemaine Harbour (see reviews in Annex V, VII, VIII: Gittings and O'Donoghue, 2011a, b, c). Evidence for this assessment is based mainly on focused studies carried out at Castlemaine Harbour in 2010 and 2011.

Conservation Objective 1 defines two types of attributes to assess conservation condition: *long term population trends* and *numbers or range (distribution) of areas used*. This assessment focuses on assessing potential impacts on the spatial distribution of waterbird species within Castlemaine Harbour and, in particular, whether the activities will cause displacement of a significant proportion of the Castlemaine Harbour population from the affected area(s). If the activities are not predicted to cause significant displacement, then the activities are not likely to affect the long term population trends. If the activities are predicted to cause significant displacement, then the activities could affect the long term population trends (but see below). In the cases where the activities are predicted to cause significant displacement, the impacts on distribution and population size are assessed separately in the Concluding Appropriate Assessment tables.

The datasets listed above allow calculation of the proportion of the Castlemaine Harbour

population that may be affected if aquaculture activities cause displacement of birds from areas occupied by aquaculture. This approach can be considered as a very simple form of habitat association model and represents a conservative form of assessment (see Stillman and Goss-Custard, 2010): the population-level consequences of displacement will depend upon the extent to which the remaining habitat is available (i.e., whether the site is at carrying capacity). In general, this assessment method "*will be pessimistic because some of the displaced birds will be able to settle elsewhere and survive in good condition*" (Stillman and Goss-Custard, 2010).

The assessment of potential disturbance impacts is based mainly on the potential for disturbance to cause displacement of birds from areas they would otherwise occupy. However, where there is limited availability of alternative habitat, or where the energetic costs of moving to alternative habitat is high, disturbance may not cause displacement of birds but may still have population-level consequences (e.g., through increased stress, or reduced food intake, leading to reduced fitness) (Gill *et al.*, 2001). However, assessing these types of potential impacts would require detailed population modelling, which would require a major research effort that is beyond the scope of this assessment.

Assessment of significance

Attribute 1 – Long term population trends

If the impact is predicted to cause spatial displacement of 25% or more of the total Castlemaine Harbour population of a species, then the impact could cause the long term population trend to show a decrease of 25% or more. Therefore, the impact would be potentially significant with reference to attribute 1 of the conservation objective.

If the long-term population trend of the species is -25% or greater and the impact is predicted to cause a level of spatial displacement that is <25%, but which is deemed to be significant (see criteria under Attribute 2), then the impact could prevent the potential recovery of the population. Therefore, the impact would be potentially significant with reference to attribute 1 of the conservation objective.

If the long-term population trend of the species is less than 25%, but the combination of the long-term population trend and the predicted spatial displacement (where the latter is assessed to be significant; see criteria under Attribute 2) would equal or exceed 25%, then the impact could cause the long term population trend to show a decrease of 25% or more. Therefore, the impact would be potentially significant with reference to attribute 1 of the conservation objective.

Attribute 2 – Number or range (distribution) of areas used

Assessing significance with reference to attribute 2 is more difficult because the level of decrease *in the numbers or range (distribution) of areas* that is considered significant has not been specified by NPWS (2011b). There are two obvious ways of specifying this threshold: (i) the value above which other studies have shown that habitat loss causes decreases in estuarine waterbird populations; and (ii) the value above which a decrease in the total Castlemaine Harbour population would be detectable against background levels of annual variation.

There have been some studies that have used individual-based models (IBMs; see Stillman and Goss-Custard, 2010) to model the effect of projected intertidal habitat loss on estuarine waterbird populations. West *et al.* (2007) modelled the effect of percentage of feeding habitat of average quality that could be lost before survivorship was affected. The threshold for the most sensitive species (Black-tailed Godwit) was 40%. Durell *et al.* (2005) found that loss of 20% of mudflat area had significant effects on Oystercatcher and Dunlin mortality and body condition, but did not affect Curlew. Stillman *et al.* (2005) found that, at mean rates of prey density recorded in the study, loss of up to 50% of the total estuary area had no influence on survival rates of any species apart from Curlew. However, under a worst-case scenario (the minimum of the 99% confidence interval of prey density), habitat loss of 2-8% of the total estuary area reduced survival rates of Grey Plover, Black-tailed Godwit, Bar-tailed Godwit, Redshank and Curlew, but not of Oystercatcher, Ringed Plover, Dunlin and Knot. Therefore, the available literature indicates that generally quite high amounts of habitat loss are required to have significant impacts on estuarine waterbird populations, and that very low levels of displacement are unlikely to cause significant impacts. However, it would be difficult to specify a threshold value from the literature.

If a given level of displacement is assumed to cause the same level of population decrease (i.e., all the displaced birds die or leave the site), then displacement will have a negative impact on the conservation status of the species. However, background levels of annual variation in recorded waterbird numbers are generally high, due to both annual variation in absolute population size and the inherent error rate in counting waterbirds in a large and complex site. Therefore, low levels of population decrease will not be detectable (even with a much higher monitoring intensity than is currently carried out). For example, a 1% decrease in the baseline population of Bar-tailed Godwit would be a decrease of four birds. The minimum error level in large-scale waterbird monitoring is considered to be around 5% (Hale, 1973; Prater, 1979; Rappoldt, 1984). Therefore, any population decrease of less than 5% is unlikely to be detectable and, for the purposes of this assessment, 5% has been taken to be the threshold value below which displacement effects are not considered

to be significant. This is a conservative threshold, as error levels combined with natural variation are likely to, in many cases; prevent detectability of higher levels of change.

Summary

Impacts have been assessed as potentially having a significant negative impact on attribute 1 of the conservation objectives (the species' long-term population trend), if they are predicted to cause:

- Displacement of 25% or more of the total Castlemaine Harbour; or
- Significant displacement levels (i.e., 5% or greater) that combined with current long-term population trends, could result in a long-term population decline of 25%; or
- Significant displacement levels (i.e., 5% or greater) where the current long-term population trends is already equal to or greater than -25%.

Impacts that will cause displacement of 5% or more of the total Castlemaine Harbour population of a SCI species have been assessed as potentially having a significant negative impact on attribute 2 of the conservation objectives (the species' distribution within Castlemaine Harbour).

Reliability

The Concluding Appropriate Assessment tables include an indication of the reliability that can be attached to the assessment of potential impact of each activity on each of the assessed species. The criteria that have been used to assess reliability are described in Table 12. For most assessments, more than one potential impact is considered for each species-activity combination, and the reliability of the impact assessments may differ between these potential impacts; in these circumstances, the lowest reliability level (for positive impacts), or highest (for negative impacts) has been used. It should be noted that there are more criteria listed for positive impacts than for negative impacts. This is because few potentially significant negative impacts were identified.

Table 12. Criteria used to assess the reliability of the impact assessment.

Reliability level	**General criteria**	**Specific criteria**
Neutral/positive impacts		

Reliability level	General criteria	Specific criteria
High	Lack of spatial/temporal overlap	Species does not occur, or very rarely occurs, in affected area and this absence is part of a broader pattern of occurrence that occurs at a larger scale than the area affected by the activity. For existing activities, it is also necessary to determine that there is no ecological reason to suspect that this absence is due to the activity
		Spatial and/or temporal pattern of activity is only likely to occasionally coincide with species (e.g., disturbance impacts) or affect less than 1% of the available habitat (e.g., existing oyster trestles)
	Species not sensitive to activity	Well-established knowledge about the ecology of the species means that the impact of the activity will be neutral or positive
	Neutral or positive response to activity	Robust evidence from studies carried out at Castlemaine Harbour, or in comparable sites, that the impact of the activity will be neutral or positive
Moderate	Probable lack of spatial/temporal overlap	Available data indicates that the species does not occur, or only rarely occurs, in the affected area but limited data, or the broader pattern of occurrence, means that there is some uncertainty about this. For existing activities, it is also necessary to determine that there is no ecological reason to suspect that this absence is due to the activity
	Probable neutral or positive response to activity	Evidence from studies carried out at Castlemaine Harbour, or in comparable sites, that the impact of the activity will be neutral or positive, but evidence based on limited data
	Potential impact not detectable	Spatial and/or temporal pattern of activity, or intensity of activity, means that maximum possible magnitude of impact (worst-case scenario) is unlikely to be detectable
Low	Potential impact probably not detectable	Spatial and/or temporal pattern of activity means that maximum possible magnitude of impact (worst-case scenario) is unlikely to be detectable, but uncertainty about this due to lack of relevant data
Negative impacts		

Reliability level	General criteria	Specific criteria
High	Negative response to activity, and response affects species distribution within the site	Statistically robust evidence from studies carried out at Castlemaine Harbour, or in comparable sites, of behavioural response to activity causing displacement of at least 5% of the Castlemaine Harbour population
Moderate	Probable negative response to activity, and response may affect species distribution within the site	Evidence from studies carried out at Castlemaine Harbour, or in comparable sites, of behavioural response to activity causing displacement of at least 5% of the Castlemaine Harbour population, but evidence based on limited data
Low	Apparent avoidance of activity	For existing activities, species does not occur in affected area and the broader pattern of spatial occurrence indicates that the species may be avoiding the area[1]
	Probable negative response to activity, but no evidence of effect on species distribution within the site	Evidence of behavioural response to activity but no evidence of displacement. However, if displacement did occur it would affect at least 5% of the Castlemaine Harbour population
	Possible negative response to activity	Behavioural response to activity considered possible from knowledge of species ecology, and displacement (if it occurred) would affect at least 5% of the Castlemaine Harbour population
	Worst-case scenario	Unrealistic worst-case scenario predicts displacement of at least 5% of the Castlemaine Harbour population

2. The status of bird populations, of special conservation interest, in the SPA

Waterbird monitoring at Castlemaine Harbour

- Waterbird populations at Castlemaine Harbour have been monitored since the 1970s (Hutchinson, 1979; Sheppard, 1993; Crowe, 2005; I-WeBS Office, 2009) and since 1994 by the Irish Wetland Bird Survey (I-WeBS). This monitoring involves monthly high tide counts between September and March of each winter. Complete counts may not be available for all months in all years.

- In the winter of 2009/10, Castlemaine Harbour was included in the NPWS Baseline Waterbird Survey Programme. As part of this programme, four low tide and one high tide count were carried out between October 2009 and February 2010, as well as a dedicated diver/seaduck survey in March 2010. These counts were in addition to routine I-WeBS monitoring.

Conservation status assessment

- There are 15 waterbird species that are listed as Special Conservation Interests (Section 3) and that are potentially affected by the proposed activities. The conservation status and trends in populations of these species was assessed using I-WeBS data. NPWS use 5 year and 13 year trends to assess the conservation status. These are calculated as follows (eg. 13 year trend) (Table 13).

    - Change = $((I_{average(2012\text{-}2014)} - I_{average(2000\text{-}2002)}) / I_{average(2000\text{-}2002)}) \times 100$

- The status of individual species can be assessed against the conservation objectives described above.
- The first mussel seed fishery natura plan was assessed in 2011 and licenced to proceed on the basis that no significant impacts on waterbirds were anticipated. iWeBs data for the duration of the first seed fishery plan (2011-2015) indicates improved status of 11 of 15 species compared to the 5 year period (2005-2010) before the plan. Three species (Common Scoter, Cormorant, Sanderling) showed small declines while Ringed plover declined by 36%.Counts of Common Scoter in particular are incomplete as it is difficult to get accurate data for this species which occurs offshore.

Table 13. Mean maximum (peak) counts per season for waterbird species at Castlemaine Harbour. Baseline, 13 year and recent 5 year trends are shown. Smoothed data are used to estimate the 13 and 5 year trends. Species in favourable conservation status (green) are stable or increasing.

Season	Bar-tailed Godwit	Common Scoter	Cormorant	Greenshank	Light-bellied Brent Goose	Mallard	Oystercatcher	Pintail	Redshank	Red-throated Diver	Ringed Plover	Sanderling	Scaup	Turnstone	Wigeon
1994/95	5	5000	150	1	200		300		15	12	30			200	
1995/96	2	7070	20	1	200	6	294		24	230	120	144	66	250	2
1996/97	330	10110	114	15	426	270	1295	255	248	45	255	303		100	5900
1997/98	2	158	30				400				20			100	
1998/99	384	500	42	120	704	531	289	100	198	1	63	337	117	60	10000
1999/00	204	235	81	5	307	411	408	20	93		51	258		50	4000
2000/01	216	186	89	13	538	631	374	12	136	5	250	208		62	4000
2001/02	**73**	**326**	**14**	**5**	**716**	**727**	**347**		**34**			**81**	**1**	**16**	**7000**
2002/03	4	246	25	26	148	110	250	19	218	12	123	100	2	70	4785
2003/04	1		25		75	2	250		40	8		30		20	
2004/05	52	411	57	7	400	63	297		172	4	12	293		18	410
2005/06	230	135	80	9	216	38	334		220	2	68	1000		22	264
2006/07	35	462	41	18	20	32	200		185	2	25	570		30	264
2007/08	23	375	29	4	253	37	384		660	1	260	58	6	70	152
2008/09	200	146	14	7	725	87	493	61	164	7	59	210	22	53	369
2009/10	300	1248	52	20	1017	415	740	67	361	23	486	420	14	45	930
2010/11	**250**	**803**	**51**	**39**	**1082**	**200**	**746**	**40**	**280**	**92**	**73**	**450**		**80**	**1200**
2011/12	115	300	33	7	757	212	604	120	250	3	67	400		86	670
2012/13	330	650	63	11	1070	970	334	45	480	4	151	690	45	55	1130
2013/14	284		5	2	621	163	332	114	641	4	27	350	1	3	2642
2014/15	437	14	34	120	749	152	600	103	850		250	300		24	3000
Smooth 2000-2003	98	253	43	15	467	489	324	16	129	9	187	130	2	49	5262
Smooth 2009-2012	222	784	45	22	952	276	697	76	297	39	209	423	14	70	933
Smooth 2012-2015	350	332	34	44	813	428	422	87	657	4	143	447	23	27	2257
Baseline	190	3043	63	31	435	370	510	97	140	70	127	250	92	104	4780
13 yr trend	259%	31%	-20%	202%	74%	-12%	30%	463%	408%	-53%	-24%	244%	1433%	-45%	-57%
5 yr trend	58%	-58%	-25%	102%	-15%	55%	-39%	15%	121%	-90%	-32%	6%	64%	-61%	142%

3. Assessment of the seed mussel fishery

Natura Impact Statement for this activity

The dredging of seed mussel and disturbance associated with this activity may reduce the quality of habitat and its suitability for waterbirds in this area of Castlemaine Harbour leading to changes in the distribution, abundance and conservation status of waterbirds.

Assessment

- The seed mussel fishery is in subtidal habitat in the outer part of Castlemaine Harbour (Figure 1).
- The Fisheries Natura Plan (Annex 1) specifies that the exploitation rate in the area fished in any year will not be greater than 66% and the exploitation rate in areas unsuitable for dredge fishing will be zero.
- Only species that feed or roost in offshore (as opposed to estuarine) subtidal habitat are potentially affected by the fishery. These are Common Scoter, Cormorant and Red-throated Diver.

Effects on prey availability for Common Scoter

Distribution:

- Common Scoter feed on benthic bivalves (including seed mussel) in water depths of less than 20m and occur in large numbers in the sea area west of Inch but not in inner Castlemaine Harbour east of Inch. The seed mussel fishery is in an area with depths of 5-11m so the fishery could potentially reduce the Common Scoter food base.
- The proposed fishery occurs on mixed sediments (Figure 4). Seed mussel recruits to this area in spring. By mid to late summer it reaches a size (5-15mm) suitable for harvesting. During autumn biomass declines either due to fishing, starfish predation or partial washout by storms. Some mussel usually survives overwinter as is evidenced in the annual seed mussel surveys.
- The distribution of the areas favoured by Common Scoter, based on the experience of a local birdwatcher over many years indicates that Common Scoter mainly occur in areas with <10m water depth. They largely avoid the central channel (where the seed mussel fishery is located), but occur regularly just to the sides of this channel (see Annex VII – Notes on Common Scoter). The main Common Scoter flock locations recorded during the 2009/10 waterbird counts were at least 1km from the 2009 seed mussel extraction area (Annex V: Gittings and O'Donoghue, 2011a). Although a flock was recorded on one date close to the area. This represented one in twelve of the flocks recorded across seven dates between September 2009 and March 2010.

- The area fished for seed mussel each year is substantially smaller than the overall extent of the area indicated as suitable (Figure 8). Interference competition is likely to limit the number of Common Scoter that can feed in this area at any one time. A large-scale study of the distribution of Common Scoter in Liverpool Bay (Kaiser *et al*., 2005) recorded a maximum density of 334 scoter per km^2. This would suggest that the areas fished annually could support a maximum of 100 scoter at any one time.
- Observations from the BIM seed surveys showing the presence of coarse sand, stone and shell, suggest that currents in the area over and surrounding the seed mussel bed are strong. Current speed is estimated to be 1.5 m/sec (3 knots; BIM, pers. comm.). A large-scale study of the distribution of Common Scoter in Liverpool Bay (Kaiser *et al*., 2005) found that scoter did not occur in areas with current speeds above 0.6 m/sec, while Woakes and Butler (1983) found that the energetic cost incurred by another diving duck (Tufted Duck) swimming against a current increased rapidly above current speeds of 0.5 m/sec. Therefore, the seed mussel bed occurs in an area that is probably unsuitable for foraging scoter.

Food consumption:

- From a literature review, Kaiser *et al*. (2005) estimated the daily consumption of Common Scoter as ranging from 600-1170g fresh weight per day. Their individual behaviour model (IBM) of Common Scoter within Liverpool Bay predicted daily consumption rates of 800-1000g per day, which is within the above range.
- The annual seed mussel surveys (Annex IV) estimated a seed mussel biomass of up to 5000 tonnes. In addition, there are non-fishable areas, not included in the survey, where the seed settles. Growth of seed leads to increase in biomass during late summer. Therefore, the biomass of seed mussel available to scoter when they arrive in July/August would generally be substantially in excess of 3500-4000 tonnes.
- For the purposes of this assessment, calculations have been carried out for two scenarios. These scenarios assumes that the seed mussel biomass of 3500 tonnes (representing an average seed biomass) is the only resource available to the entire baseline population of Common Scoter for a period of:
    - One month (i.e., the period between the seed mussel fishery and the seed mussel being washed out by autumn storms); or
    - Seven months (i.e., the period between the seed mussel fishery and the beginning of the departure of the scoter flock at the end of March).
- Calculations show (Table 14) that, even under average spat fall conditions, the scoters' monthly consumption would be 2-4% and the overwinter consumption would be 13-26% of the June 2010 seed mussel biomass.
- As the fishery will not take more than 66% of the fishable seed mussel stock, while

additional seed mussel biomass will be available in the unfishable areas and scoters will not be entirely reliant on the seed mussels as a food source, it is clear that the seed mussel fishery will not affect the availability of food resources for the scoter.

Table 14. Calculation of the potential consumption of seed mussel by Common Scoter in Castlemaine Harbour.

Parameter	Units	Min	Max
Daily consumption (Kaiser 2005)	g fresh weight	600	1170
Daily consumption of 3637 scoter (baseline population)	g fresh weight	2,182,200	4,255,290
Monthly consumption	g fresh weight	65,466,000	127,658,700
Monthly consumption	tonnes fresh weight	65	128
Overwinter consumption (Sept-March)	tonnes fresh weight	458	894
Biomass of seed mussel bed[3]	tonnes	3500	3500
Maximum % monthly consumption by scoter		2%	4%
Maximum % overwinter consumption by scoter		13%	26%

Effects on food base for Cormorant and Red-throated Diver

- Cormorant and Red-throated Diver are fish-eating species so the seed mussel fishery will not potentially reduce its food base. They occur in low numbers and generally not in areas where the seed fishery is proposed.

Disturbance

- All three sub-tidal SCI species could potentially be affected by disturbance from boat traffic generated by dredging. However, dredging takes place over a short period of time so any disturbance impacts will be of short duration and will not affect the availability of resources in this area.

Conclusion

The appropriate assessment of the seed mussel fishery is summarised in Table 15.

Mitigation

No mitigation actions are proposed.

Table 15. Concluding Appropriate Assessment in relation to effects of the seed mussel fishery.

Species affected	Attributes	Attributes following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Light-bellied Brent Goose, Wigeon, Mallard and Scaup	Population distribution and size	No change	None	Does not occur in this part of Castlemaine Harbour	NPWS 2009/10 waterbird counts	High
Common Scoter	Population distribution and size	No change	None	Seed mussel bed in an area that is not regularly used by scoter and where the habitat is unsuitable for scoter due to the current speed Maximum allowed exploitation rate of fishery will leave ample seed mussel biomass to support the entire baseline scoter population Dredging takes place over a short period of time so any disturbance impacts will be of short duration and will not affect the availability of resources in this area	Fishery plan and seed mussel survey Note on Common Scoter (O'Clery, 2011) NPWS 2009/10 waterbird counts Kaiser *et al.* (2005,2006)	High
Cormorant and Red-throated Diver	Population distribution and size	No change	None	Dredging takes place over a short period of time so any disturbance impacts will be of short duration and will not affect the availability of resources in this area	Fishery plan NPWS 2009/10 waterbird counts	High
Oystercatcher, Ringed Plover, Sanderling, Bar-tailed Godwit, Greenshank, Redshank and Turnstone	Population distribution and size	No change	None	Do not occur in subtidal habitat	Species ecology	High

4. Assessment of the effects of intertidal mussel relay: effects of mussel cover on habitat suitability for waterbirds

Natura impact statement for this activity

The relay of intertidal mussels and subsequent dredging of it within the mussel nursery area and or mussel aquaculture sites may reduce the quality of habitat and its suitability for waterbird species of Special Conservation Interest in this area of Castlemaine Harbour leading to changes in the distribution, abundance and conservation status of these species.

Data sources

- iWeBs (2014) high tide count data
- NPWS 2009/10 waterbird counts
- Annex V: Gittings and O'Donoghue (2011a). These data explore the relationship between the mussel nursery and habitat use by birds.
- GIS data on locations of mussel licenced sites and intertidal nursery area

Assessment

- The following assessment is based on the results of survey work carried out in the winter of 2009/10 (Gittings and O'Donoghue, 2011a). Therefore, this assessment refers to the level of mussel on-growing carried out during that winter, and, in particular, to overall mussel cover in the nursery area of 12%. The potential impacts from significantly higher levels of mussel ongrowing/cover have not been assessed. Monitoring of mussel cover during the period 2011-2014 indicates that mussel cover on intertidal habitats resulting from implementation of the 2011-2015 mussel seed fishery natura plan has not exceeded 12%. The work of Gittings and O'Donoghue (2011a) remains relevant therefore.
- Common Scoter and Scaup do not occur in this part of Castlemaine Harbour and are not considered further in this assessment.

Baseline condition of habitat

- The mussel nursery area is part of a larger mussel bed of apparently natural origin, which has existed in this area for over 100 years (Crowley, 1973; Lee, 1975). This mussel bed is classified as a mussel biotope (LS.LBR.LMus.Myt.Sa) (O'Connor 2004).
- The seed mussel fishery began in 1994 and prior to this date, no intertidal relay of mussels occurred within the mussel nursery area. Relaying of seed mussels onto the mussel biotope is equivalent to the biotope receiving natural spatfall which would

increase the existing mussel cover

- Therefore, the baseline condition of the mussel nursery area is not an open sandflat with no mussel cover, but some undetermined and variable level of mussel cover. In recent years MI surveys have found various levels of mussel cover but generally less than 12%. Mussels in the north of the intertidal relay area and seaward of this area are generally seed which is relaid sub-tidally while mussels in the south of the nursery area are a mix of seed and fully grown mussels. It is not clear whether these fully grown mussels are the result of previous relays or represent natural settlement as part of a mussel biotope.

Distribution of waterbird species in the mussel nursery area

- Low tide counts and locations of flocks of waterbirds in the intertidal area east of Inch, which includes the mussel nursery area, were carried out in 2009/10
- This section of Castlemaine Harbour was particularly important for Light-bellied Brent Goose and Pintail, holding 50% or more of the Castlemaine Harbour populations of these species. Generally the area held more than its expected (based on the geographic area of the habitat as a proportion of total available intertidal habitat in the harbour) proportion of populations of all SCI waterbird species that use intertidal habitat.
- Detailed transect counts within the seed mussel nursery area indicates that the mussel nursery area is used by significant components of the Castlemaine populations of Light-bellied Brent Goose, Sanderling, Bar-tailed Godwit, Redshank, Turnstone and Herring Gull.
- Comparison of detailed transect counts within the seed mussel nursery area with overall counts for the wider area containing the nursery area (i.e., the low tide count sectors OK444, OK445 and OK447) indicates that Light-bellied Brent Goose and most wader species occurred in numbers equal to or greater than predicted by the availability of intertidal habitat, while Bar-tailed Godwit, Redshank and Turnstone occur in numbers equal to or greater than predicted by the availability of tideline habitat.
- Ringed Plover were very rare, or absent, during the transect counts despite occurring in significant numbers in the count sectors containing the nursery area. This species mainly feeds on open sandflats and so would be expected to avoid habitat with mussel.
- Wigeon, Mallard and Pintail were very rare, or absent, during the transect counts despite occurring in significant numbers in the count sectors. This probably reflects their association with freshwater inflows and proximity to saltmarsh (NPWS, 2011).
- The percentage occurrence of Red-throated Diver and Cormorant in the vicinity of the nursery area was broadly in line with the percentage expected if the birds were

randomly distributed across the sub-tidal habitat covered by the survey.

- High tide roost locations are distant from the intertidal nursery area.

Distribution of waterbird species in relation to mussel cover

- The percentage of the intertidal nursery area that is covered with mussel is on average 12% or less.
- The response of bird populations to different levels of mussel cover is unlikely to be linear. The following assessment considers the effects of an average of 12% cover. Increases in this percentage may have positive effects on the use of this habitat resource by some species and negative effects on others.
- Mussel aquaculture sites are presumed to be used to the same degree as the intertidal nursery for relay of seed and the assessment by Gittings and O'Donoghue (2011a) in the intertidal nursery area can be applied to effects of intertidal relay in the aquaculture sites
- Oystercatcher and Redshank were positively associated with mussel cover. Similarly, a Welsh study found that intertidal mussel relay caused an increase in numbers of Redshank, although Oystercatcher numbers were not affected (Caldow *et al*., 2003). There is some evidence to suggest that Light-bellied Brent were also positively associated with mussel cover at the within-sector scale. Turnstone are also likely to be positively associated with mussel cover, given their general habitat preferences.
- There is some evidence to suggest Sanderling and Bar-tailed Godwit were negatively associated with mussel cover. It is unlikely that the change in mussel cover between the baseline condition and that found during 2011-2015 would have affected the use of the nursery area by these species. However, it is possible that a substantial increase in mussel cover above the 2011-2015 level could cause displacement of these species. These species have increased in numbers in Castlemaine harbour in recent years.

Conclusion

The appropriate assessment of relaying and dredging of mussels in the intertidal area is summarised in Table 16.

Mitigation

No mitigation actions are proposed unless mussel cover significantly exceed 12% cover.

Table 16. Concluding Appropriate Assessment in relation to the effects of an average of 12% mussel cover on habitat suitability for waterbirds in intertidal habitats.

Species affected	Attributes	Attributes following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Light-bellied Brent Goose, Greenshank and Turnstone	Population trend and distribution	No change	None	Distribution in the affected area is as expected; the area holds representative proportions of their populations in the area taking account of habitat conditions. Light-bellied Brent Goose and Turnstone were positively associated with mussel cover at the within-sector scale. Greenshank and Turnstone regularly feed in mussel beds.	NPWS count data 2009/10 Annex V: Gittings and O'Donoghue (2011a) transect counts	Moderate
Wigeon, Mallard and Pintail	Population trend and distribution	No change	None	Does not use the intertidal zone occupied by the mussel nursery area. Absence due to habitat associations with freshwater inflows and proximity to saltmarsh, rather than avoidance of mussel cover.	NPWS count data 2009/10 Annex V: Gittings and O'Donoghue (2011a) transect counts	Moderate

Species affected	Attributes	Attributes following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Common Scoter, Red-throated Diver and Cormorant	Population trend and distribution	No change	None	Common Scoter does not occur in the inner part of Castlemaine Harbour (i.e. east of Cromane Point). Percentage occurrence of Red-throated Diver and Cormorant in vicinity of nursery area broadly in line with the percentage expected if the birds were randomly distributed across the subtidal habitat covered by the survey.	NPWS count data 2009/10	High
Oystercatcher and Redshank	Population trend and distribution	Increase or No change	None	Positively associated with mussel cover at both the within-sector and between-sector scales.	NPWS count data 2009/10 Annex V: Gittings and O'Donoghue (2011a) transect counts	High
Ringed Plover	Population trend and distribution	No change	None	Very rare, or absent, in the nursery area during the transect counts despite occurring in significant numbers in the count sectors containing the nursery area. Feeds on open sandflats and so would be expected to avoid the mussel biotope, even in the absence of any intertidal relay.	NPWS count data 2009/10 Annex V: Gittings and O'Donoghue (2011a) transect counts	Moderate

Species affected	Attributes	Attributes following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Sanderling and Bar-tailed Godwit	Population trend and distribution	No change	None	Distribution in the affected area is as expected: the area holds representative proportions of their populations, taking account of habitat conditions. May avoid mussel patches at small spatial scales. But it is unlikely that recent mussel cover levels resulting from seed relays would have affected their use of the nursery area.	NPWS count data 2009/10 Annex V: Gittings and O'Donoghue (2011a) transect counts	Moderate

5. Assessment of intertidal relay of mussels in the mussel order area: Effects of human disturbance

Natura impact statement for this activity

- Human activities associated with mussel production in the nursery area may disturb birds to the extent that their use of the SPA is reduced, their distribution within the SPA is modified or reduced or the energetic costs associated with the disturbance reduces subsequent fitness, breeding success and survival.

Data sources

- Comparison of the seasonal distribution in the occurrence of bird populations at the site (I-WeBS) and expected levels of human activity derived from the draft Natura fishery management plan using the method of Bell (2008) (Annex IX).
- Annex V: Gittings and O'Donoghue (2011a). Bird studies at Castlemaine Harbour 2010. These data explore the relationship between the mussel nursery and habitat use by birds and the effects of human disturbance on bird distribution.

Assessment

- Wigeon, Mallard, Pintail, Common Scoter and Ringed Plover do not regularly occur within, or in close proximity, to the nursery area. Therefore, these species are not considered further in this assessment.
- The modelling of the effects of individual disturbance events is based on the results of survey work carried out in February and March 2010. Therefore, the assessment from this modelling refers to the level of activity that occurred during this period. The potential impacts from significantly higher levels of activity (due to seasonal variation in activity and or higher levels of mussel ongrowing) have not been assessed but given the levels of mussel production 2011-2015 it is unlikely that disturbance levels have increased.

Disturbance at low tide to intertidal habitat

- Coincidence (in time) of disturbance caused by activities associated with mussel production and the potential time that bird populations can use the habitat in the SPA is on average 3-6% for waders and up to 12% for a number of other species. These estimates are gross overestimates as they assume that any disturbance event and its effects persist for the duration of a tidal period and apply throughout the site (see Annex IX).
- Mussel production related disturbance activities occurred on four out of the five survey

days and affected a mean of 6.8% of the available habitat resource, using an alert response distance, and 2.4% using a flight response distance. Comparisons with relevant studies in the scientific literature show that these levels of disturbance are generally much lower than levels reported to affect survivorship (Annex V: Gittings and O'Donoghue, 2011a).

- These potential disturbance effects are overestimates of the actual disturbance impacts for a number of reasons. The actual mean disturbance impact per low tide period is expected to be lower by 50-75%, and probably below the lower end of that range for a number of reasons as outlined in Annex V (Gittings and O'Donoghue 2011a).

Disturbance at high tide to subtidal habitat

- The percentage occurrence of Red-throated Diver and Cormorant in subtidal habitat in the vicinity of nursery area was broadly in line with the percentage expected if the birds were randomly distributed across the subtidal habitat covered by the survey.
- The populations of these species are dispersed throughout the site and only a small area will be affected by dredging at any one time.

Conclusions

The appropriate assessment of disturbance is summarised in Table 17.

Mitigation

No mitigation actions are proposed.

Table 17. Concluding Appropriate Assessment in relation to effects of human disturbance associated with intertidal mussel relay on the habitat use and distribution of SCI waterbird species.

Species affected	**FCS Parameter**	**FCS following proposed activity**	**Significance of impact (if negative)**	**Rationale**	**Supporting evidence**	**Reliability**
Light-bellied Brent Goose, Oystercatcher, Sanderling, Bar-tailed Godwit, Redshank, Greenshank and Turnstone	Population distribution and size	Stable	None	Indices of coincidence (overlap) in habitat use of bird populations and human activity associated with mussel production is low Modelling of individual disturbance events show that a very low % of the available habitat is affected Do not use the nursery area at high tide when dredging occurs	I-WeBs data on seasonal distribution of bird populations in the SPA Expected disturbance activity generated by the draft mussel Fishery Natura plan Modelling of the spatial extent of individual disturbance events (Annex V: Gittings and O'Donoghue, 2011a)	Moderate
Wigeon, Mallard, Pintail, Scaup, Common Scoter and Ringed Plover	Population distribution and size	Stable	None	Do not regularly occur within, or in close proximity to the nursery area	NPWS count data 2009/10 Annex V: Gittings and O'Donoghue (2011a) transect counts	High

Species affected	FCS Parameter	FCS following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Red-throated Diver and Cormorant	Population distribution and size	Stable	None	Do not use the nursery area at low tide. Percentage occurrence of Red-throated Diver and Cormorant in subtidal habitat in the vicinity of nursery area broadly in line with the percentage expected if the birds were randomly distributed across the subtidal habitat covered by the survey. Populations dispersed throughout the site and only a small area will be affected by dredging at any one time.	NPWS count data 2009/10 Annex V: Gittings and O'Donoghue (2011a) transect counts	High

6. Assessment of sub-tidal relaying of mussels

Natura impact statement for this activity

- The subtidal relaying of seed mussel and disturbance associated with this activity, within the mussel order area or in sub-tidal portions of the mussel aquaculture sites, may reduce the quality of habitat and its suitability for waterbirds in this area of Castlemaine Harbour leading to changes in the distribution, abundance and conservation status of waterbirds.

Data sources

- NPWS 2009/10 waterbird counts (reviewed in Annex V: Gittings and O'Donoghue, 2011a).
- Annex V: Gittings and O'Donoghue (2011a).

Assessment

Effects on prey

- Common Scoter does not occur in this part of Castlemaine Harbour and are not considered further in this assessment.
- Habitat changes caused by subtidal mussel relay could potentially affect the habitat quality for species that feed in benthic zones of subtidal habitat in this area. These species are Scaup, Red-throated Diver and Cormorant.
- Scaup mainly feed on molluscs in depths of up to 6m. Therefore, subtidal relay of mussels will increase their food supply and is likely to have a neutral or positive effect on this species.
- Red-throated Diver and Cormorant are fish-eating species. In the case of Red-throated Diver NPWS found that they occur in the outer bay to the west of Rossbehy Peninsula (i.e. OK915. OK916 and OK917) and to the west of Inch Strand (OK918). They also occur to the west of Cromane (OK473 and OK474) in the inner harbour. However, they favour OK915 and OK917 in the outer bay rather than the relay area. NPWS found little pattern in the foraging distribution of Cormorant with birds recorded throughout the harbour. Furthermore, only a small area will be affected by dredging at any one time. The relaying of mussels within the bay should not affect prey availability in these areas. It may even result in a short term increase in crabs and other scavengers feeding on mussels damaged by the relay operation, which may in turn provide a food resource or attract foraging fish species which both diver and Cormorant in turn could feed on.

Disturbance

- Disturbance caused by relay of mussels into the subtidal plots and harvesting of mussels from these plots could potentially affect the habitat quality for species that feed or roost in subtidal habitat and/or species that roost at high tide on the shoreline close to the relay plots.
- In addition to the species mentioned above, Light-bellied Brent Goose, Wigeon, Mallard and Pintail may feed or roost in subtidal habitat. When these species use subtidal habitat, they usually occur in shallow water, or close to the tideline.
- Small high tide roosts of Oystercatcher and Greenshank have been recorded along the northern shore of Castlemaine Harbour close to the main subtidal relay area. Redshank and Turnstone are also likely to roost in this area.
- Detailed information on waterbird responses to these activities has not been collected, but a reasonable assessment can be made from the nature of the activities involved and knowledge of the ecology of the species potentially affected.
- Relay of mussels into the subtidal plots takes place in spring/early summer. Waterbird numbers are low during this period so any disturbance from this activity is not likely to have significant impacts.
- As the vessels used for dredging mussels from the subtidal plots are large, they are restricted to relatively deep water. They are, therefore, unlikely to cause disturbance to waterbirds using shallow subtidal habitat, or roosting on the shoreline.
- The populations of Red-throated Diver and Cormorant are dispersed throughout the site and only a small area will be affected by dredging at any one time.
- Scaup occur in the vicinity of the subtidal relay plots on the eastern side of Cromane Point. Dredging will only affect a small area of the available habitat at any one time. As there is only a small group of Scaup present at Castlemaine, and Scaup usually feed in flocks, there will be ample alternative habitat for the Scaup to utilise, without being displaced from this area.
- The main subtidal relay area extends to within 100 m of a high tide roost at Lack Point. This does not appear to be a major roost site. Furthermore, roosting waders generally habituate to vehicular disturbance, while, if disturbance does occur, there are alternative roost sites nearby.

Conclusions

The appropriate assessment of sub-tidal relay within the mussel order area is summarised in Table 18.

Mitigation

No mitigation actions are proposed.

Table 18. Concluding Appropriate Assessment in relation to effects of subtidal mussel relay within the mussel order area on the habitat use and distribution of SCI waterbird species.

Species affected	FCS Parameter	FCS following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Light-bellied Brent Goose, Wigeon, Mallard and Pintail	Population distribution and size	No change	None	Feeding habitat not affected Relay of mussels into subtidal plots takes place outside main period of occurrence Vessels used for dredging mussels restricted to deep water	Fishery plan Species ecology	High
Scaup	Population distribution and size	No change/ Increase	None	Feed on molluscs Relay of mussels into subtidal plots takes place outside main period of occurrence Dredging will only affect a small area of the available habitat at any one time and there will be ample alternative habitat	Fishery plan Species ecology	High
Common Scoter	Population distribution and size	No change	None	Does not occur in affected areas	NPWS count data 2009/10	High

Species affected	FCS Parameter	FCS following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Red-throated Diver and Cormorant	Population distribution and size	Stable	None	Fish-eating species Relay of mussels into subtidal plots takes place outside main period of occurrence particularly for Red-throated Diver Populations dispersed throughout the site and only a small area will be affected by dredging at any one time.	NPWS count data 2009/10 Fishery Plan Species ecology	High
Oystercatcher, Redshank, Greenshank and Turnstone	Population distribution and size	Stable	None	Relay of mussels into subtidal plots takes place outside main period of occurrence High tide roost near subtidal relay is not a major roost site. Roosting waders generally habituate to vehicular disturbance Alternative roost sites nearby.	NPWS count data 2009/10 Fishery Plan	High
Sanderling and Bar-tailed Godwit	Population distribution and size	Stable	None	No high tide roosts near subtidal relay plots	NPWS count data 2009/10	High

7. Assessment of sub-tidal relaying in mussel aquaculture licenses outside the mussel order area

Natura Impact Statement for this activity

The relay of mussels, subsequent dredging and associated human disturbance, outside the mussel order area, may reduce the quality of habitat and its suitability for waterbird species in this area of Castlemaine Harbour leading to changes in the distribution, abundance and conservation status of these species.

Data sources

- NPWS 2009/10 waterbird counts (reviewed in Annex V: Gittings and O'Donoghue, 2011b).

Assessment

- The mussel licenses covering sub-tidal habitat occur along the northern side of the harbour, between Lack Point and Roscullen Island (9 licences) and on the southern side between Douglas Strand and Dromgorm Point (9 licences).
- Pintail, Common Scoter and Red-throated Diver do not occur in the areas in the vicinity of these licenses and license applications, and are not considered further in this assessment.

Subtidal feeding habitat

- Habitat changes caused by subtidal mussel relay could potentially affect the habitat quality for species that feed in benthic zones of subtidal habitat in this area. These species are Scaup and Cormorant.
- Scaup mainly feed on molluscs in depths of up to 6m. Therefore, subtidal relay of mussels is likely to have a neutral or positive effect on this species.
- Cormorant is a fish-eating species. As noted Cormorant are dispersed throughout the site. Subtidal license and license application areas were not recorded as being of note for Cormorant by NPWS. Growth of mussels in these areas may even result in a short term increase in crabs and other scavengers feeding on mussels damaged by the relay operation, which may in turn provide a food resource or attract foraging fish species which Cormorant could in turn feed on.

Disturbance

- Disturbance caused by relay of mussels into the subtidal plots and harvesting of mussels from these plots could potentially affect the habitat quality for species that

feed or roost in subtidal habitat and/or species that roost at high tide on the shoreline close to the relay plots.

- In addition to the species mentioned above, Light-bellied Brent Goose, Wigeon and Mallard may feed or roost in subtidal habitat. When these species use subtidal habitat, they usually occur in shallow water, or close to the tideline.
- Small high tide roosts of Mallard, Oystercatcher and Turnstone have been recorded along the northern shore of Castlemaine Harbour close to the main subtidal relay area. Redshank and Greenshank are also likely to roost in this area. Small high tide roosts of Wigeon, Mallard, Oystercatcher, Redshank and Greenshank have been recorded along the southern shore of Castlemaine Harbour close to subtidal relay areas.
- Detailed information on waterbird responses to these activities has not been collected, but a reasonable assessment can be made from the nature of the activities and knowledge of the ecology of the species potentially affected.
- Relay of mussels into the subtidal plots takes place in spring/early summer (in 2010, it occurred in April and early May). Waterbird numbers are low during this period so any disturbance impacts from this activity are not likely to have significant effects on the conservation status of waterbird species in Castlemaine Harbour.
- There was only once count of two Scaup from the area in the vicinity of these licenses occur. Therefore, these areas are probably not important for Scaup.
- The populations of Cormorant are dispersed throughout the site and only a small area will be affected by dredging at any one time.
- One subtidal license on the northern shore extends to within 150 m of a high tide roost near Gortaleen. This does not appear to be a major roost site. Furthermore, roosting waders generally habituate to vehicular disturbance, while, if disturbance does occur, there are alternative roost sites nearby.
- The nearest subtidal license on the southern shore is over 200 m from the nearest mapped roost site. However, saltmarsh, which provides potential roosting habitat, extends to within a few metres of two licenses. However, if disturbance does occur, there are alternative saltmarsh roost sites nearby.

Conclusions

The appropriate assessment of intertidal mussel relay outside the mussel order area is summarised in Table 19.

Mitigation

No mitigation actions are proposed.

Table 19. Concluding Appropriate Assessment in relation to effects of subtidal mussel relay outside the mussel order area on the habitat use and distribution of SCI waterbird species.

Species affected	FCS Parameter	FCS following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Light-bellied Brent Goose, Wigeon and Mallard	Population distribution and size	No change	None	Feeding habitat not affected Relay of mussels into subtidal plots takes place outside main period of occurrence Vessels used for dredging mussels restricted to deep water High tide roosts (Wigeon and Mallard) near subtidal relay are not major roost sites. Alternative roost sites nearby	Fishery plan Species ecology	High
Pintail, Common Scoter and Red-throated Diver	Population distribution and size	No change	None	Does not occur in affected areas	NPWS count data 2009/10	High

Species affected	FCS Parameter	FCS following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Scaup	Population distribution and size	No change/ Increase	None	Feed on molluscs Relay of mussels into subtidal plots takes place outside main period of occurrence Dredging will only affect a small area of the available habitat at any one time and there will be ample alternative habitat	Fishery plan Species ecology	High
Cormorant	Population distribution and size	Stable	None	Fish-eating species Relay of mussels into subtidal plots takes place outside main period of occurrence Populations dispersed throughout the site and only a small area will be affected by dredging at any one time.	NPWS count data 2009/10 Fishery Plan Species ecology	High

Species affected	FCS Parameter	FCS following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Oystercatcher, Redshank, Greenshank and Turnstone	Population distribution and size	Stable	None	Relay of mussels into subtidal plots takes place outside main period of occurrence High tide roosts near subtidal relay are not major roost sites. Roosting waders generally habituate to vehicular disturbance Alternative roost sites nearby.	NPWS count data 2009/10 Fishery Plan	High
Sanderling and Bar-tailed Godwit	Population distribution and size	Stable	None	No high tide roosts near subtidal relay plots	NPWS count data 2009/10	High

8. Assessment of intertidal relaying of seed mussel in mussel licenses outside the mussel order area

Natura impact statement for this activity

The relay of intertidal mussels, subsequent dredging of it and associated human disturbance, outside the mussel order area, may reduce the quality of habitat and its suitability for waterbird species of Special Conservation Interest in this area of Castlemaine Harbour leading to changes in the distribution, abundance and conservation status of these species.

Data sources

- iWebs (2014) data
- NPWS 2009/10 waterbird counts (Gittings and O'Donoghue, 2011b).
- Gittings and O'Donoghue (2011a, 2011b).

Assessment

- The predictions made in this assessment are based on limited data and combine datasets from two winters, and there is no data on species distribution within the Douglas Strand-Cromane area during the autumn/early winter period.
- Information about the potential extent of intertidal mussel relay is based on interpretation of license application positions, rather than information supplied by the license applicants, and may not be definitive.
- Pintail and Common Scoter were not recorded in the Douglas Strand-Cromane area in the NPWS 2009/10 or the oyster study 2011 counts and are not considered further in this assessment.

Distribution of intertidal mussel relay outside the mussel order area

- 9 intertidal mussel licenses outside the mussel order area occur within the Douglas Strand-Cromane area of Castlemaine Harbour. These licences occupy an area of 72ha, which is around 10% of the total area of intertidal habitat in the Douglas Strand-Cromane area.

Potential displacement effects on waterbirds feeding on intertidal habitat

- Light-bellied Brent Goose, Wigeon, Mallard, Oystercatcher, Ringed Plover, Sanderling, Bar-tailed Godwit, Redshank, Greenshank and Turnstone feed on intertidal habitat in this area.
- Oystercatcher and Redshank, and probably also Light-bellied Brent Goose,

Greenshank and Turnstone, show a positive response to the presence of intertidal mussel cultivation.

- Ringed Plover, and possibly also Sanderling and Bar-tailed Godwit, may show a negative response to the presence of intertidal mussel cultivation. However, recent 5 year trends for bar-tailed godwit and sanderling are positive suggesting that the previous fishing plan (2011-2015) and additional mussel licences since 2011 did not negatively affect these species
- The response of Wigeon and Mallard to intertidal mussel cultivation is not known. Recent 5 year trends for Wigeon and Mallard are positive.
- Ringed Plover and Sanderling were not recorded in the main areas potentially affected by mussel aquaculture licences.
- Nearly 50% of the Castlemaine Harbour population of Bar-tailed Godwit occurred in the Douglas Strand-Cromane in 2009/10, but none occurred here during the 2011 study. Therefore, the overall importance of this area for Bar-tailed Godwits is unclear. The evidence for Bar-tailed Godwit having a negative response to intertidal mussel cultivation is their possible negative association with mussel cover in the mussel nursery area. However, at levels of mussel cover comparable to those within the mussel nursery area, it is unlikely that Bar-tailed Godwit would be displaced from areas used for intertidal mussel cultivation (see assessment of intertidal relay within the mussel order area). Recent iWeBs trend data shows increases in numbers of this species.

Potential disturbance effects on waterbirds feeding on intertidal habitat

- Mussel production related disturbance activities affected a small proportion of the available habitat resource in the nursery area (see above). Therefore, mussel production related disturbance activities are unlikely to have significant impacts in the Douglas Strand-Cromane area.

Effects on waterbirds roosting on intertidal and shoreline habitat

- Cormorant roost on the outer sandbanks in this area.
- These sandbanks are large and the area used is well away from the mussel licenses. Therefore, intertidal mussel cultivation will not restrict the availability of habitat for roosting Cormorants.
- The Cormorants mainly roost on intertidal habitat away from the tideline. Therefore, they are unlikely to be affected by disturbance from boats accessing areas of intertidal mussel cultivation.
- There are a number of high tide roosts, used by various duck and wader species (including Wigeon, Mallard, Oystercatcher, Redshank, Greenshank and Turnstone), along the Douglas Strand-Cromane shoreline (Figure 13). Most work on intertidal

mussel relay beds takes place at low tide and will not affect high tide roosts. Relay of mussels into the intertidal plots and dredging of mussel from the intertidal are activities of short duration and, in the latter case, takes place outside the main period when of occurrence of the SCI species.

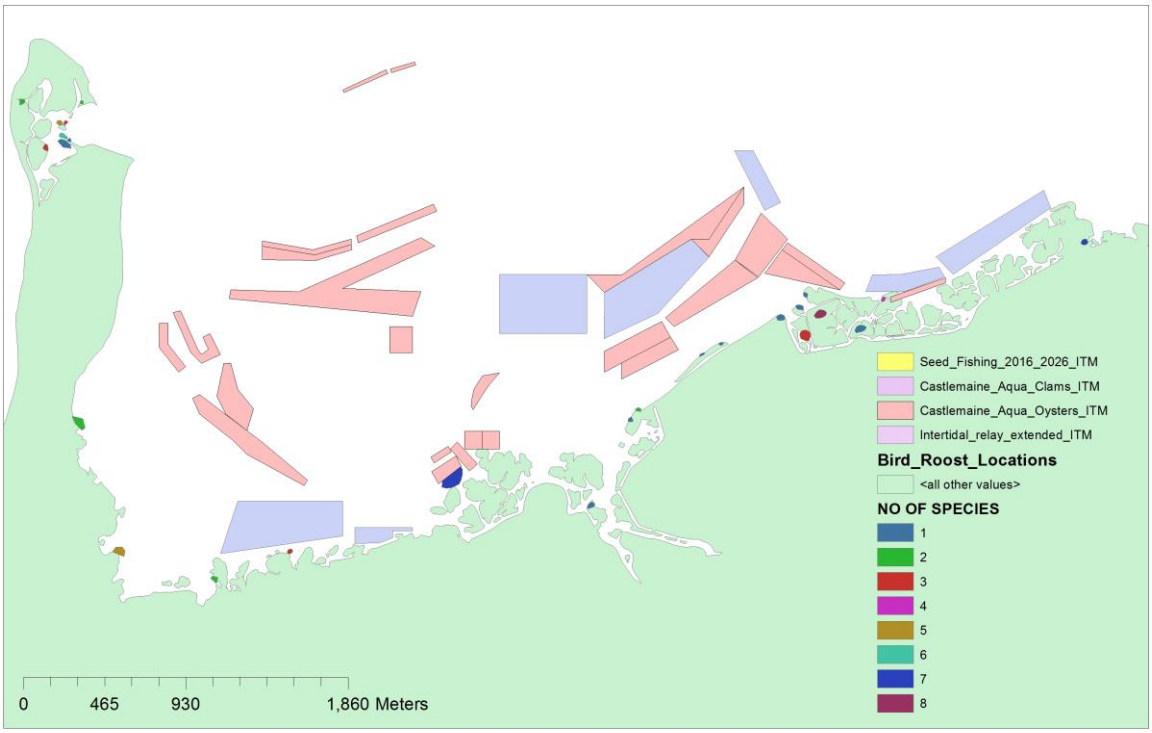

Figure 13. Distribution of high tide bird roosts in the Douglas Strand Cromane shore line in Castlemaine harbour in relation to licenced mussel and oyster aquaculture sites. The number of species using the roost sites is indicated.

Effects on waterbirds using subtidal habitat

- Scaup, Red-throated Diver and Cormorant use subtidal habitat in this area.
- These species could possibly be affected by disturbance from boats being used to access oyster trestles. However, this disturbance will be infrequent and each incidence will be of very short duration (i.e., while the boat is passing the birds).

Conclusions

The appropriate assessment of intertidal mussel relaying outside the mussel order area is summarised in Table 20.

Mitigation

No mitigation actions are proposed.

Table 20. Concluding Appropriate Assessment in relation to effects of intertidal mussel relaying outside the mussel order area.

Species affected	**FCS Parameter**	**FCS following proposed activity**	**Significance of impact (if negative)**	**Rationale**	**Supporting evidence**	**Reliability**
Light-bellied Brent Goose, Oystercatcher, Redshank, Greenshank and Turnstone	Population distribution and size	Stable/Increase	None	Positive response to intertidal mussel cultivation Mussel production related disturbance activities likely to affect a very low % of the available intertidal habitat and will not affect high tide roosts	NPWS 2009/10 waterbird counts. Annex V,VII: Gittings and O'Donoghue (2011a, b)	High (Oystercatcher and Redshank) Moderate (Light-bellied Brent Goose, Greenshank and Turnstone)
Wigeon and Mallard	Population distribution and size	Stable	None	Response to intertidal mussel cultivation not known Worst-case displacement scenario (probably unrealistic) would affect up to 3% of the Castlemaine Harbour population and any resulting impacts unlikely to be detectable Mussel production related disturbance activities likely to affect a very low % of the available intertidal habitat and will not affect high tide roosts	NPWS 2009/10 waterbird counts. Annex V,VII: Gittings and O'Donoghue (2011a, b)	Moderate
Pintail and Common Scoter	Population distribution and size	Stable	None	Does not occur in the Douglas Strand-Cromane area	NPWS 2009/10 waterbird counts. Annex VII: Gittings and O'Donoghue (2011b)	High

Species affected	FCS Parameter	FCS following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Scaup and Red-throated Diver	Population distribution and size	Stable	None	Does not feed in intertidal habitat. Any disturbance to birds in subtidal habitat from boats will be infrequent and each incidence will be of very short duration	NPWS 2009/10 waterbird counts. Annex VII: Gittings and O'Donoghue (2011b)	High
Cormorant	Population distribution and size	Stable	None	Does not feed in intertidal habitat. Roosts on outer sandbanks away from intertidal mussel cultivation Any disturbance to birds in subtidal habitat from boats will be infrequent and each incidence will be of very short duration	NPWS 2009/10 waterbird counts. Annex VII: Gittings and O'Donoghue (2011b)	High
Ringed Plover and Sanderling	Population distribution and size	Stable	None	Does not occur in the main areas affected or potentially affected by license applications Limited data on distribution within the Douglas Strand-Cromane area	NPWS 2009/10 waterbird counts. Annex VII: Gittings and O'Donoghue (2011b)	Moderate

Species affected	FCS Parameter	FCS following proposed activity	Significance of impact (if negative)	Rationale	Supporting evidence	Reliability
Bar-tailed Godwit	Population distribution	Stable/Decrease	None / Significant	Possible negative response to intertidal mussel cultivation Worst-case scenario (probably unrealistic) would cause displacement of up to 5% of the Castlemaine Harbour population Mussel production related disturbance activities likely to affect a very low % of the available intertidal habitat	NPWS 2009/10 waterbird counts. Annex VII: Gittings and O'Donoghue (2011b)	Low
Bar-tailed Godwit	Population size	Stable/Decrease	None / Significant	Effect of displacement on population size will depend on whether populations are at carrying capacity	NPWS 2009/10 waterbird counts. Annex VII: Gittings and O'Donoghue (2011b)	Low

9. Assessment of potential for in combination effects of aquaculture activities

Natura Impact Statement for this activity

The combination of existing mussel, oyster and clam cultivation may reduce the quality of habitat and its suitability for waterbird species of Special Conservation Interest in leading to changes in the distribution, abundance and conservation status of these species.

Data sources

- NPWS 2009/10 waterbird counts.
- Annex V, VII, VIII: Gittings and O'Donoghue (2011a, b, c).

Assessment

- The following is based on the assessments of individual activities and these latter assessments should be consulted for full details of the individual impacts.

Wigeon and Mallard

- Recent trends show increases in Wigeon and Mallard in Castlemaine.
- Wigeon and Mallard are not affected by intertidal mussel cultivation in the mussel order area. In this part of Castlemaine Harbour, they mainly occur in the upper shore zone, away from the nursery area, due to their association with freshwater inflows, saltmarsh and shoreline algal zones (NPWS, 2011b)
- In the Douglas Strand-Cromane area, upper shoreline zones are affected, or potentially affected by intertidal mussel and oyster cultivation. The nature of the response of Wigeon and Mallard to intertidal mussel and oyster cultivation is not known. Both species, therefore, could potentially be negatively affected by displacement from intertidal habitat due to intertidal mussel and oyster cultivation in the Douglas Strand-Cromane area.
- These species have relatively widespread distributions both across Castlemaine Harbour (NPWS, 2011b) and within the Douglas Strand-Cromane area (Gittings and O'Donoghue, 2011b), so small levels of displacement are unlikely to cause significant increases in displacement in the remaining areas of suitable habitat.
- No significant disturbance impacts to these species have been identified. Therefore, disturbance is unlikely to increase the cumulative impacts discussed above.

Ringed Plover and Sanderling

- Long and short term trends for sanderling are positive in Castlemaine. Trends for

Ringed plover are moderately negative.

- The existing location and level of clam production (zero in 2012-2015) will not have any negative effect on ringed plover or sanderling (Annex VIII).
- The existing level of intertidal mussel cultivation in the mussel nursery area is not considered to have a significant impact on either species. However, a substantial increase in the level of mussel cover could potentially reduce habitat suitability for Sanderling. As the levels are probably 12% or less such an impact is unlikely.
- Intertidal mussel cultivation in the intertidal mussel licences in the Douglas Strand-Cromane area is not likely to cause impact, as these species do not use the affected areas.
- No significant disturbance impacts to these species have been identified. Therefore, disturbance is unlikely to increase the cumulative impacts discussed above.

Bar-tailed Godwit

- Long and short term trends for Bar tailed godwit are positive in Castlemaine.
- Bar-tailed Godwits are potentially negatively affected by displacement from intertidal habitat due to intertidal mussel cultivation and intertidal oyster cultivation.
- Intertidal mussel and oyster cultivation in the Douglas Strand-Cromane area could cause displacement of 12% of the Castlemaine Harbour population (Gittings and O'Donoghue, 2011a).
- This species has a restricted distribution at Castlemaine Harbour (NPWS, 2011b), so displacement from areas affected by intertidal mussel and oyster cultivation in the Douglas Strand-Cromane area could cause a significant increase in density in the remaining areas of suitable habitat. However, given that mussel cover within mussel aquaculture licences and the fishery order is not expected to exceed 12% no significant displacement is likely to occur.

Other species

- No effects are likely to occur on other species

Mitigation

No mitigation actions are proposed.

10. Assessment of potential for cumulative impacts: in association with aquaculture

Natura Impact Statement for this activity

The combination of existing mussel, oyster and clam cultivation and impacts from other activities may reduce the quality of habitat and its suitability for waterbird species of Special Conservation Interest in leading to changes in the distribution, abundance and conservation status of these species.

Data sources

- NPWS 2009/10 waterbird counts.
- Annex V, VII, VIII: Gittings and O'Donoghue (2011a, b).

Assessment

- The other activities included in this Appropriate Assessment are:
  - Predator control
  - Hand collection of shellfish
  - Effluent discharge
  - Recreation

Predator control

- Predator control (of crabs) takes place in subtidal habitats (and in the lower intertidal at high tide) in the mussel order area.
- Crabs in subtidal habitat are not a significant food resource for any of the SCI species, although it is a minor prey item for Red-throated Diver (BWPi, 2004).
- This is a low intensity activity (generally only a single boat on any one day) and is unlikely to cause significant disturbance to any species.

Hand collection of shellfish

- Hand collection of periwinkles (winkle picking) takes place in, and around the mussel nursery area, and at Rossbehy Creek.
- Hand collection of periwinkles around the mussel nursery area mainly takes place in the southern part of the nursery area and in adjoining areas to the south and west.
- Hand collection of periwinkles at Rossbehy Creek occurs in the upper shore area to the south-east of the clam licence.
- Hand collection of cockles takes place north east of the clam licenced area. One gatherer is involved.
- The potential impact, if any of, hand collection of shellfish on food resources for

waterbirds in Castlemaine Harbour is not known. Cockles are an important food resource for larger waders such as Oystercatcher, but the cockle bed in Rossbehy Creek does not appear to be important for these species and exploitation rates by gatherers are low.

- Disturbance from winkle picking could potentially have cumulative impacts with disturbance from mussel-related activities in the mussel nursery area. However, it is a low intensity activity and groups of winkle pickers tend to work within the same area, so the potential level of impact is low.

Effluent discharge

- Organic and nutrient inputs to estuaries increase productivity and may increase food resources for waterbirds. Adverse impacts to waterbirds may be caused by declines in organic and nutrient inputs, although there is no hard evidence to date of this happening (Burton *et al*., 2003). Therefore, effluent discharges to Castlemaine Harbour are unlikely to cause adverse impacts to waterbirds.

Recreation

- Detailed information on recreational activities and their impacts on waterbirds within Castlemaine Harbour are not available.
- The main areas used for general recreation are the beach along the western side of Inch dunes, both sides of the sand dunes at Rossbehy and Cromane Strand.
- Recreational activities could cause disturbance to waterbird species. The species that are most likely to be affected are waders that feed on upper sandy beaches; i.e., in term of Fossitt (2000), LS2 and the drier end of the habitat variation included under LS3. Of the SCI species, these include Oystercatcher, Ringed Plover and Sanderling.
- The potential impacts of the aquaculture activities on Oystercatcher are neutral or positive, so cumulative impacts are not an issue for the appropriate assessment of this species.
- Ringed Plover and Sanderling may be adversely affected by intertidal clam and mussel aquaculture. These species were recorded on Inch Beach during the 2009/10 counts. At Rossbehy Creek, their main feeding area is away from the areas affected by recreational activities, but they feed on the eastern side of the dunes when their main feeding grounds are covered, and they may roost somewhere along these dunes.
- There have been several studies of the impacts of recreational disturbance of wader distribution in sandy beaches. This type of disturbance may affect the foraging behaviour of waders: e.g., Thomas *et al*. (2003) found that that the number and activity of people significantly reduced the amount of time spent foraging by

Sanderling on sandy beaches in California. However, several studies have found no evidence that recreational disturbance affects the spatial distribution of waders on sandy beaches (Colwell and Sundeen, 2000; Lafferty, 2001; Yasué, 2006; Neuman *et al*., 2008), while Trulio and Sokale (2008) found no effect on intertidal mudflats from trail use around San Francisco Bay. Several of these papers include Sanderling and Semi-palmated Plover (closely related to Ringed Plover) among the species assemblages studied. In particular, Neuman *et al*., (2008) specifically report a lack of any effect of recreational disturbance on Sanderling distribution in Monterey Bay.

- Therefore, given the amount of evidence from the scientific literature, it seems unlikely that recreational disturbance is having significant impacts on the spatial distribution of Ringed Plover and Sanderling in Castlemaine Harbour.

Mitigation

No mitigation actions are proposed.

11. Assessment of the effects of mussel production on Conservation Objective 2 for the SPA.

Conservation Objective 2

Conservation Objective 2 for the Castlemaine Harbour Special Protection Area is defined as follows: -

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.

This objective is defined by the following attribute and targets:-

To be favourable the permanent area occupied by the wetland habitat should be stable and not significantly less than the areas of 7472, 3983 & 322 hectares for subtidal, intertidal and supratidal habitats respectively, other than that occurring from natural patterns of variation. These areas are defined by SPA boundary to MLWN, MLWM to MHWM, and MHWM to SPA boundary (the latter value is minus the sand dunes at Inch and Rossbehy) as illustrated in the Ordnance Survey Discovery 1:50,000 series database (NPWS 2011b).

Assessment

The aquaculture activities considered in this assessment take place in intertidal and subtidal habitat and do not significantly disturb these habitats according to SAC conservation objective guidance as shown above. Therefore, these activities will not affect the attributes and targets specified for conservation objective 2.

Section 8 - AA Conclusion Statement

1. SAC Features

- The proposed seed mussel fishery and subsequent mussel relay and production activities is nursery areas and in licenced mussel sites in Castlmaine Harbour SAC overlap with some conservation features in the SAC. Overlaps with individual sedimentary marine communities are generally less than 15% of these communities and are therefore considered, relative to the conservation objectives, to be not-significant. Where % overlap is greater than 15% (sub-tidal relay) the % of the habitat directly affected is low.
- Overlap with seagrass is 0% and indirect effects on seagrass are not envisaged. Monitoring data shows that this habitat is stable.
- Oyster trestle culture is not disturbing to benthic habitats at the scale of operation in Castlemaine Harbour and effects of this activity are not-significant. No in combination effects are envisaged.
- Mussel and oyster or clam production is not likely to have any impact on Salmon, Otter, Lamprey, by virtue of the fact that no spatial overlap with attributes or no direct or indirect interaction are envisaged.
- No mitigations are proposed for the activities described in the mussel seed fishery natura plan.

2. SPA Features

- The proposed seed fishery is not likely to significantly effect Common Scoter.
- Relay of seed mussel on intertidal nursery areas and intertidal portions of mussel aquaculture licences will overlap with <15% of intertidal habitat. Within this area mussel cover is expected to be generally less than 12%. At this level of relay no significant effects on waterbirds are expected.
- In combination effects of mussel, oyster and clam production are not anticipated given the current scale of production.
- The status of waterbirds in Castlemaine Harbour generally improved during the period of implementation of the first mussel seed fishery natura plan 2011-2015 compared to years prior to this. The plan proposed for 2016-2026 is similar. There is a high degree of confidence therefore that the 2016-2026 plan will not negatively affect waterbirds in Castlemaine Harbour.

3. Recommendations

- Although no significant effects are envisaged count data for Common Scoter in Castlemaine is weak and should be improved during the lifetime of the seed mussel fishery natura plan
- A substantial increase in mussel cover within the mussel nursery area or in mussel aquaculture sites could have significant impacts on some species such as Sanderling and Bar-tailed Godwit. Mussel cover should be monitored and if necessary managed to avoid significant displacement of these species.

Section 9 - References SAC interests

Bell, M. C. (2008). A framework for analysis of interactions and conflict between UK bivalve fisheries and bird populations. Report to RSPB, 121pp.

Bouchet, V.M.P. and Sauriau, P-G. (2008). Influence of oyster culture practices and environmental conditions on the ecological status of intertidal mudflats in the Pertuis Charentais (SW France): A multi-index approach. Marine Pollution Bulletin 56, 1898-1912.

Crowe, O. (2005) Ireland's wetlands and their waterbirds: status and distribution BirdWatch Ireland, Newcastle, Co. Wicklow.

Cummins, S. & Crowe, O. (2010) Collection of baseline waterbird data for Irish coastal Special Protection Areas 1: Castlemaine Harbour, Tralee Bay, Lough Gill & Akeragh Lough, Dundalk Bay, Bannow Bay, Dungarvan Harbour & Blackwater Estuary Unpublished report commissioned by the National Parks and Wildlife Service, and prepared by BirdWatch Ireland.

Dare, P. J., Bell, M. C., Walker, P. and Bannister, R., 2004. Historical and current status of cockle and mussel stocks in The Wash. CEFAS, Lowestoft, pp. 85.

DEHLG (2009). Appropriate assessment of projects and plans in Ireland. Guidance for planning authorities. DEHLG, Dublin, 83pp.

Dernie, K.M., Kaiser, M.J. and Warwick, R.M. (2003).Recovery rates of benthic communities following physical disturbance. Journal of Animal Ecology, 72, 1043-1056.

Forde, J., O'Beirn, F., O'Carroll, J.PJ., Patterson, A. and Kennedy, R.(2015). Impacts of intertidal oyster trestle cultivation on the ecological status of benthic habitats. Marine Pollution Bulletin, http://dx.doi.org/10.1016/j.marpolbul.2015.04.013.

Gittings, T. & O'Donoghue, P.D. (2010). Castlemaine Waterbird Report, 2010. Draft Report prepared for the Marine Institute. Atkins, Cork.

Hilgerloh, G., O'Halloran, J., Kelly, T.C. and Burnell, G.M. (2001). A preliminary study on the effects of oyster culturing structures on birds in a sheltered Irish estuary. Hydrobiologia, 465: 175-180.

I-WeBs (2014). I-WeBs counts at Castlemaine Harbour 1994-2014. I-WeBs office.

Kochmann, J. F. O'Beirn, J. Yearsley and T.P. Crowe. 2013. Environmental factors associated with invasion: modeling occurrence data from a coordinated sampling programme for Pacific oysters. Biological Invasions 15:2265-2279.

Kochmann, J. and T.P. Crowe. 2014. Effects of native macroalgae and predators on survival, condition and growth of non-indigenous Pacific oysters (*Crassostrea gigas*).

Journal of xperimental Marine Biology and Ecology. 451:122-129

NPWS (2009) Baseline Waterbird Surveys within Irish Coastal Special Protection Areas – Draft Survey Methods and Guidance Notes National Parks and Wildlife Service.

NPWS (2011a). Castlemaine Harbour SAC (site 343). Conservation Objectives supporting document – marine habitats. NPWS, Version 2.

Nugues, M.M., Kaiser, M.J. , Spencer, B.E and Edwards D.B. (1996). Benthic community changes associated with oyster cultivation. Aquaculture Research, 27, 913-924.

Saurel, C. Gascoigne, J. and Kaiser M.J. (2004). The ecology of seed mussel beds. Literature review. Project FC1015, School of Ocean Sciences, University of Bangor UK

Section 10 - References SPA interests

Bell, M. C. (2008). *A framework for analysis of interactions and conflict between UK bivalve fisheries and bird populations*. Report to RSPB, 121pp.

Bouchet, V.M.P. and Sauriau, P-G. (2008). Influence of oyster culture practices and environmental conditions on the ecological status of intertidal mudflats in the Pertuis Charentais (SW France): A multi-index approach. *Marine Pollution Bulletin* 56, 1898-1912.

Burton, N.H.K., Jones, T.E., Austin, G.E., Watt, G.A. & Rehfisch, M.M. (2003). *Effects of reductions in organic and nutrient loading on bird populations in estuaries and coastal waters of England and Wales: Phase 2 report*. English Nature Research Report No. 586. English Nature, Peterborough.

Burton, N.H.K., Musgrove, A.J. & Rehfisch, M.M. (2004). Tidal variation in numbers of waterbirds: how frequently should birds be counted to detect change and do low tide counts provide a realistic average? *Bird Study*, 51, 48-57.

BWPi (2004). *Birds of the Western Palearctic Interactive*. Bird Guides Ltd.

Caldow, R.W.G., Beadman, H.A., McGrorty, S., Kaiser, M.J., Goss-Custard, J.D., Mould, K. & Wilson, A. (2003). Effects of intertidal mussel cultivation on bird assemblages. *Marine Ecology Progress Series*, 259, 173-183.

Colwell, M.A. & Sundeen, K.D. (2000). Shorebird Distributions on Ocean Beaches of Northern California (Distribución de Aves Playeras en las Playas Oceánicas del Norte de California). *Journal of Field Ornithology*, 71, 1-15.

Crowe, O. (2005). *Ireland's wetlands and their waterbirds: status and distribution*. BirdWatch Ireland, Newcastle, Co. Wicklow.

Crowe, O., Austin, G.E., Colhoun, K., Cranswick, P.A., Kershaw, M. & Musgrove, A.J. (2008). Estimates and trends of waterbird numbers wintering in Ireland, 1994/95 to 2003/04. *Bird Study*, 55, 66-77.

Crowley, M. (1973). *Fishery Leaflet No. 46. Shellfish survey of Castlemaine Harbour (Cromane)*. Fisheries Division, Dublin.

Cummins, S. & Crowe, O. (2010). *Collection of baseline waterbird data for Irish coastal Special Protection Areas 1: Castlemaine Harbour, Tralee Bay, Lough Gill & Akeragh Lough, Dundalk Bay, Bannow Bay, Dungarvan Harbour & Blackwater Estuary* Unpublished report commissioned by the National Parks and Wildlife Service, and prepared by BirdWatch Ireland.

Dare, P. J., Bell, M. C., Walker, P. and Bannister, R. (2004). *Historical and current status of cockle and mussel stocks in The Wash*. CEFAS, Lowestoft, pp. 85.

Dernie, K.M., Kaiser, M.J. and Warwick, R.M. (2003).Recovery rates of benthic

communities following physical disturbance. *Journal of Animal Ecology*, 72, 1043-1056.

Durell, S.E.A. le V. dit, Stillman, R., Triplet, P., Aulert, C., Ditbiot, D., Bouchet, A., Duhamel, S., Mayot, S. & Gosscustard, J. (2005). Modelling the efficacy of proposed mitigation areas for shorebirds: a case study on the Seine estuary. France. *Biological Conservation*, 123, 67-77.

Gill, J., Norris, K. & Sutherland, W.J. (2001). Why behavioural responses may not reflect the population consequences of human disturbance. *Biological Conservation*, 97, 265-268.

Gittings, T. & O'Donoghue, P. (2011a). *Marine Institute Bird Studies (Castlemaine) Project. Assessment of the potential effects of mussel ongrowing within the mussel order area and of the mussel seed fishery on the waterbird populations of Castlemaine Harbour*. Unpublished report to the Marine Institute. Atkins, Cork.

Gittings, T. & O'Donoghue, P. (2011b). *Marine Institute Bird Studies (Castlemaine Appropriate Assessment). Preliminary assessment of the potential effects of oyster cultivation and additional intertidal mussel relay on the spatial distribution of waterbirds in Castlemaine Harbour.* Unpublished report to the Marine Institute. Atkins, Cork.

Goss-Custard, J.D., Stillman, R.A., West, A.D., Caldow, R.W.G., Triplet, P., Durell, S.E.A. le V. dit & McGrorty, S. (2004). When enough is not enough: shorebirds and shellfishing. *Proceedings of the Royal Society of London* B, 271, 233-7.

Hale, W.G. (1974). Aerial counting of waders. *Ibis* 116:412. (cited by Prater, 1979).

Hilgerloh, G., O'Halloran, J., Kelly, T.C. and Burnell, G.M. (2001). A preliminary study on the effects of oyster culturing structures on birds in a sheltered Irish estuary. *Hydrobiologia*, 465: 175-180.

Hutchinson, C.D. (1979). *Ireland's wetlands and their birds*. Irish Wildbird Conservancy, Dublin.

I-WeBs (2014). *I-WeBs counts at Castlemaine Harbour 1994-2014*. I-WeBs office.

Kaiser, M., Elliott, A., Galanidi, M., Rees, E.I.S., Caldow, R., Stillman, R., Sutherland, W.J. & Showler, D.A. (2005). *Predicting the displacement of common scoter* Melanitta nigra *from benthic feeding areas due to offshore windfarms*. University of Wales Bangor report to COWRIE.

Kaiser, M.J., Galanidi, M., Showler, D.A., Elliott, A.J., Caldow, R.W.G., Rees, E.I.S., Stillman, R.A. & Sutherland, W.J. (2006). Distribution and behaviour of Common Scoter *Melanitta nigra* relative to prey resources and environmental parameters. *Ibis*, 148, 110-128.

Lafferty, K. (2001). Birds at a Southern California beach: seasonality, habitat use and

disturbance by human activity. *Biodiversity and Conservation*, 10, 1949-1962.

Lee, T. (1975). A survey of the mussel (*Mytilus edulis*) stocks in Castlemaine Harbour, 17th November - 5th December, 1975. Bord Iascaigh Mhara, Dublin.

NPWS (2009). *Baseline Waterbird Surveys within Irish Coastal Special Protection Areas – Draft Survey Methods and Guidance Notes*. National Parks and Wildlife Service.

NPWS (2011b). Castlemaine Harbour SPA (site 4029). Conservation Objectives supporting document. NPWS, Version 2.

Neuman, K.K., Henkel, L.A. & Page, G.W. (2008). Shorebird use of sandy beaches in central California. Waterbirds: *The International Journal of Waterbird Biology*, 31, 115-121.

Nugues, M.M., Kaiser, M.J., Spencer, B.E and Edwards D.B. (1996). Benthic community changes associated with oyster cultivation. *Aquaculture Research*, 27, 913-924.

Prater, A.J. (1979). Trends in accuracy of counting birds. *Bird Study*, 26, 198-200.

Rappoldt, C., Kersten, M. & Smit, C. (1985). Errors in large-scale shorebird counts. *Ardea*, 73, 13-24.

Saurel, C. Gascoigne, J. and Kaiser M.J. (2004). *The ecology of seed mussel beds. Literature review*. Project FC1015, School of Ocean Sciences, University of Bangor UK

Sheppard, R. (1983). *Ireland's Wetland Wealth*. Irish Wildbird Conservancy, Dublin.

Stillman, R.A. & Goss-Custard, J.D. (2010). Individual-based ecology of coastal birds. *Biological Reviews*, 85, 413-434.

Stillman, R.A., West, A.D., Goss-Custard, J.D., McGrorty, S., Frost, N.J., Morrisey, D.J., Kenny, A.J. & Drewitt, A.L. (2005). Predicting site quality for shorebird communities: a case study on the Humber estuary, UK. *Marine Ecology Progress Series*, 305, 203-217.

Thomas, K., Kvitek, R.G. & Bretz, C. (2003). Effects of human activity on the foraging behavior of sanderlings *Calidris alba*. *Biological Conservation*, 109, 67-71.

Trulio, L.A. & Sokale, J. (2008). Foraging Shorebird Response to Trail Use Around San Francisco Bay. *Journal of Wildlife Management*, 72, 1775-1780.

West, A.D., Yates, M.G., McGrorty, S. & Stillman, R.A. (2007). *Predicting site quality for shorebird communities: A case study on the Wash embayment*, UK. Ecological Modelling, 202, 527-539.

Woakes, A.J. & Butler, P.J. (1983).Swimming and diving in tufted ducks *Aythya fuligula*, with particular reference to heart rate and gas exchange. *Journal of Experimental Biology*, 107, 311-329. (quoted by Kaiser *et al.*, 2005).

Yasué, M. (2006). Environmental factors and spatial scale influence shorebirds' responses to human disturbance. *Biological Conservation*, 128, 47-54.