Rinville,
Oranmore,
Co. Galway
Tel: 091 387200
Date: 06 June 2019

Deirdre Fitzpatrick
Aquaculture and Foreshore Management Division
Department of Agriculture, Food and the Marine
Clogheen,
Clonakilty
Co. Cork.

Advice on Aquaculture Licence Application

Applicant	**Shamrock Shellfish Ltd**
Application type	**New**
Site Reference No	**T06/495A**
Species	**Mussels (M. edulis) - longlines**
Site Status	**Located within the Kenmare River SAC (Site Code 002158)** **Located within the Kilmakillogue designated Shellfish Growing Waters Area.**

Dear Deirdre

This is an application for an aquaculture licence to cultivate mussels (*M. edulis*) using longlines at Site T06/495A in Kenmare Bay, Co. Kerry. The area of foreshore at Site T06/495A is circa 2.5 Ha

No chemicals or hazardous substances will be used during the production process.

The cultivation of shellfish at this site will produce faeces and pseudofaeces. Any impact will be limited to the area of the site. The build-up of excess organic matter beyond the footprint of the site is not considered likely.

Considering the location, nature and scale of the proposed aquaculture activity, and in deference to our remit under the Marine Institute Act, and the considerations implicit to Sections 61(e and f) of the Fisheries (Amendment) Act, 1997 the Marine Institute is of the view that there will be no significant impacts on the marine environment and that the quality status of the area will not be adversely impacted

Site T06/495A is located within the Kilmakillogue designated Shellfish Growing Water Area.

Under Annex II of EU Regulation 854/2004 mussels in the Kilmakillogue area currently have a seasonal "A" Classification from 1st December – 1st May and revert to a "B" Classification at all other times

Site T06/495A is located within the Kenmare River SAC (Site Code 002158)

We note the findings of the Appropriate Assessment report[1] and the Department's draft Natura conclusion statement[2] in regard to the impacts on the Conservation Objectives within the Kenmare River SAC.

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1 https://www.agriculture.gov.ie/media/migration/seafood/aquacultureforeshoremanagement/aquaculturelicensing/aquacultureforeshorelicenceapplications/cork/2019/AppropAssessofAquacultandFisheriesRiskAssessinKenmareRiverSAC270319.pdf

2 https://www.agriculture.gov.ie/media/migration/seafood/aquacultureforeshoremanagement/aquaculturelicensing/appropriateassessmentconclusionstatement/DRAFTAACONCLUSIONSTATEMENT260319.pdf

In making the final determination with respect to this application it is recommended that DAFM take full account of the conclusions and recommendations of the Appropriate Assessment report and the proposed mitigation measures set out in the Department's Draft Natura Conclusion Statement.

In order to be able to assess and manage the potential risk of the introduction of invasive non-native species the MI recommends that the initial source of seed and other sources which may be used at any point in the future should be approved by the Minister. This approval should be a specific condition of any licence that may issue. It should be noted that the control of alien species is a separate issue to the control of diseases in the context of the current Fish Health legislation.

Notwithstanding the recommendation outlined above, and in the event that an Aquaculture Licence is granted, the movement of stock in and out of the site should follow best practice guidelines as they relate to the risk of introduction of invasive non-native species (e.g. Invasive Species Ireland). In this regard it is recommended that, prior to the commencement of operations at the site, the applicant be required to draw up a contingency plan, for the approval of DAFM, which shall identify, *inter alia*, methods for the removal from the environment of any invasive non-native species introduced as a result of operations at this site. If such an event occurs, the contingency plan shall be implemented immediately.

In the event that invasive non-native species are introduced into a site as a result of aquaculture activity the impacts may be bay -wide and thus affect other aquaculture operators in the bay. In this regard, therefore, the Marine Institute considers that the CLAMS process may be a useful and appropriate vehicle for the development and implementation of alien species management and control plans.

It is statutory requirement that a Fish Health Authorisation as required under Council Directive 2006/88/EC be in place prior to the commencement of the aquaculture activities proposed.

Kind regards,

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Dr. Terry McMahon
Section Manager, Marine Environment and Food Safety Services,
The Marine Institute.

☑ Shellfish Waters Directive Area

☑ Aquaculture Site

☑ Special Area of Conservation

☑ Special Protection Areas

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Aquaculture and Foreshore Management Division
Department of Agriculture, Food and the Marine
Clogheen,
Clonakilty
Co. Cork.

Advice on Aquaculture Licence Application

Applicant	**Shamrock Shellfish Ltd**
Application type	**New**
Site Reference No	**T06/254A**
Species	**Mussels (M. edulis) - longlines**
Site Status	**Located within the Kenmare River SAC (Site Code 002158)** **Located within the Kilmakillogue designated Shellfish Growing Waters Area**.

Dear Deirdre

This is an application for an aquaculture licence to cultivate mussels (*M. edulis*) using longlines at Site T06/254A in Kenmare Bay, Co. Kerry. The area of foreshore at Site T06/254A is circa 2.0 Ha

No chemicals or hazardous substances will be used during the production process.

The cultivation of shellfish at this site will produce faeces and pseudofaeces. Any impact will be limited to the area of the site. The build-up of excess organic matter beyond the footprint of the site is not considered likely.

Considering the location, nature and scale of the proposed aquaculture activity, and in deference to our remit under the Marine Institute Act, and the considerations implicit to Sections 61(e and f) of the Fisheries (Amendment) Act, 1997 the Marine Institute is of the view that there will be no significant impacts on the marine environment and that the quality status of the area will not be adversely impacted

Site T06/254A is located within the Kilmakillogue designated Shellfish Growing Water Area.

Under Annex II of EU Regulation 854/2004 mussels in the Kilmakillogue area currently have a seasonal "A" Classification from 1st December – 1st May and revert to a "B" Classification at all other times

Site T06/254A is located within the Kenmare River SAC (Site Code 002158)

We note the findings of the Appropriate Assessment report[1] and the Department's draft Natura conclusion statement[2] in regard to the impacts on the Conservation Objectives within the Kenmare River SAC.

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In making the final determination with respect to this application it is recommended that DAFM take full account of the conclusions and recommendations of the Appropriate Assessment report and the proposed mitigation measures set out in the Department's Draft Natura Conclusion Statement.

In order to be able to assess and manage the potential risk of the introduction of invasive non-native species the MI recommends that the initial source of seed and other sources which may be used at any point in the future should be approved by the Minister. This approval should be a specific condition of any licence that may issue. It should be noted that the control of alien species is a separate issue to the control of diseases in the context of the current Fish Health legislation.

Notwithstanding the recommendation outlined above, and in the event that an Aquaculture Licence is granted, the movement of stock in and out of the site should follow best practice guidelines as they relate to the risk of introduction of invasive non-native species (e.g. Invasive Species Ireland). In this regard it is recommended that, prior to the commencement of operations at the site, the applicant be required to draw up a contingency plan, for the approval of DAFM, which shall identify, *inter alia*, methods for the removal from the environment of any invasive non-native species introduced as a result of operations at this site. If such an event occurs, the contingency plan shall be implemented immediately.

In the event that invasive non-native species are introduced into a site as a result of aquaculture activity the impacts may be bay -wide and thus affect other aquaculture operators in the bay. In this regard, therefore, the Marine Institute considers that the CLAMS process may be a useful and appropriate vehicle for the development and implementation of alien species management and control plans.

It is statutory requirement that a Fish Health Authorisation as required under Council Directive 2006/88/EC be in place prior to the commencement of the aquaculture activities proposed.

Kind regards,

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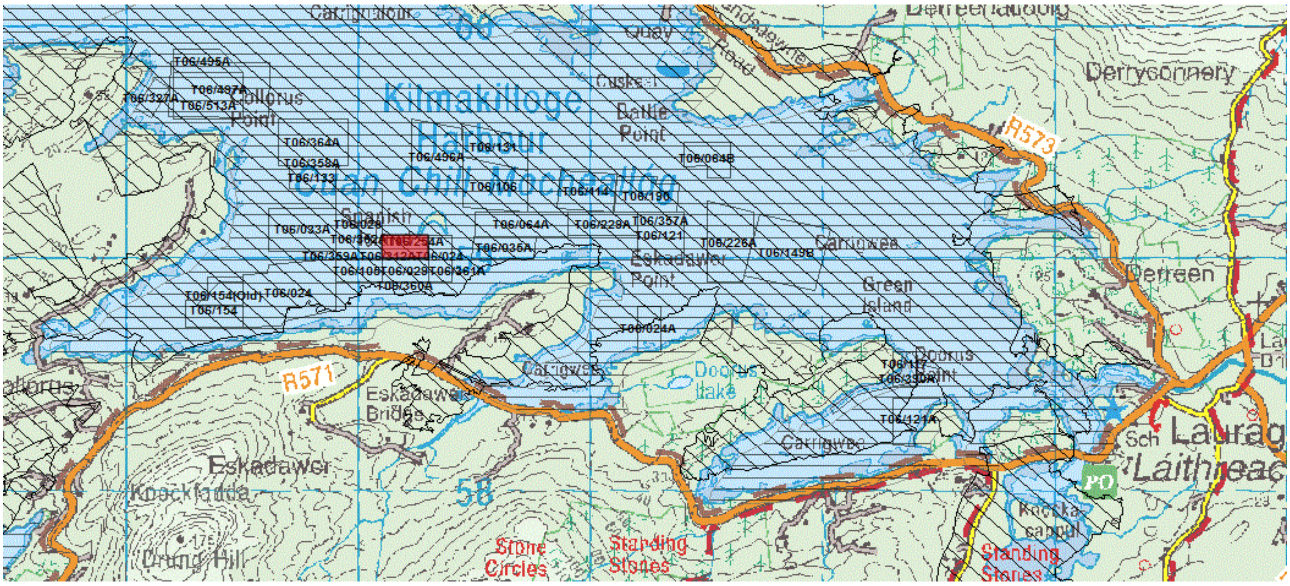
Dr. Terry McMahon
Section Manager, Marine Environment and Food Safety Services,
The Marine Institute.



☑ Shellfish Waters Directive Area

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Department of Agriculture, Food and the Marine
Clogheen,
Clonakilty
Co. Cork.

Advice on Aquaculture Licence Application

Applicant	**Shamrock Shellfish Ltd**
Application type	**Renewal**
Site Reference No	**T06/106**
Species	**Mussels (M. edulis) - longlines**
Site Status	**Located within the Kenmare River SAC (Site Code 002158)** **Located within the Kilmakillogue designated Shellfish Growing Waters Area.**

Dear Deirdre

This is an application for the renewal of an aquaculture licence to cultivate mussels (*M. edulis*) using longlines at Site T06/106 in Kenmare Bay, Co. Kerry. The area of foreshore at Site T06/106 is circa 5.50 Ha

No chemicals or hazardous substances will be used during the production process.

The cultivation of shellfish at this site will produce faeces and pseudofaeces. Any impact will be limited to the area of the site. The build-up of excess organic matter beyond the footprint of the site is not considered likely.

Considering the location, nature and scale of the proposed aquaculture activity, and in deference to our remit under the Marine Institute Act, and the considerations implicit to Sections 61(e and f) of the Fisheries (Amendment) Act, 1997 the Marine Institute is of the view that there will be no significant impacts on the marine environment and that the quality status of the area will not be adversely impacted

Site T06/106 is located within the Kilmakillogue designated Shellfish Growing Water Area.

Under Annex II of EU Regulation 854/2004 mussels in the Kilmakillogue area currently have a seasonal "A" Classification from 1st December – 1st May and revert to a "B" Classification at all other times

Site T06/106 is located within the Kenmare River SAC (Site Code 002158)

We note the findings of the Appropriate Assessment report[1] and the Department's draft Natura conclusion statement[2] in regard to the impacts on the Conservation Objectives within the Kenmare River SAC.

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In making the final determination with respect to this application it is recommended that DAFM take full account of the conclusions and recommendations of the Appropriate Assessment report and the proposed mitigation measures set out in the Department's Draft Natura Conclusion Statement.

In order to be able to assess and manage the potential risk of the introduction of invasive non-native species the MI recommends that the initial source of seed and other sources which may be used at any point in the future should be approved by the Minister. This approval should be a specific condition of any licence that may issue. It should be noted that the control of alien species is a separate issue to the control of diseases in the context of the current Fish Health legislation.

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In the event that invasive non-native species are introduced into a site as a result of aquaculture activity the impacts may be bay -wide and thus affect other aquaculture operators in the bay. In this regard, therefore, the Marine Institute considers that the CLAMS process may be a useful and appropriate vehicle for the development and implementation of alien species management and control plans.

It is statutory requirement that a Fish Health Authorisation as required under Council Directive 2006/88/EC be in place prior to the commencement of the aquaculture activities proposed.

Kind regards,

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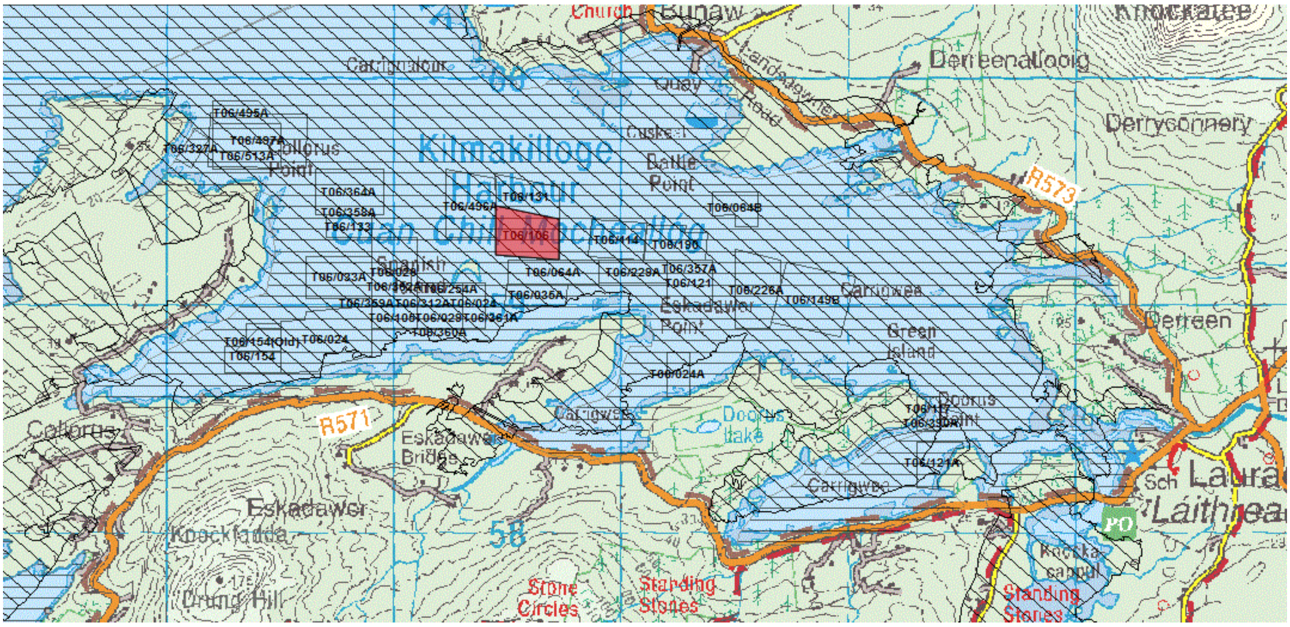

☑ Shellfish Waters Directive Area

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Department of Agriculture, Food and the Marine
Clogheen,
Clonakilty
Co. Cork.

Advice on Aquaculture Licence Application

Applicant	**Shamrock Shellfish Ltd**
Application type	**Renewal**
Site Reference No	**T06/035A**
Species	**Mussels (M. edulis) - longlines**
Site Status	**Located within the Kenmare River SAC (Site Code 002158)** **Located within the Kilmakillogue designated Shellfish Growing Waters Area**.

Dear Deirdre

This is an application for the renewal of an aquaculture licence to cultivate mussels (*M. edulis*) using longlines at Site T06/035A in Kenmare Bay, Co. Kerry. The area of foreshore at Site T06/035A is circa 2.63 Ha

No chemicals or hazardous substances will be used during the production process.

The cultivation of shellfish at this site will produce faeces and pseudofaeces. Any impact will be limited to the area of the site. The build-up of excess organic matter beyond the footprint of the site is not considered likely.

Considering the location, nature and scale of the proposed aquaculture activity, and in deference to our remit under the Marine Institute Act, and the considerations implicit to Sections 61(e and f) of the Fisheries (Amendment) Act, 1997 the Marine Institute is of the view that there will be no significant impacts on the marine environment and that the quality status of the area will not be adversely impacted

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Kind regards,

Tery McMahon

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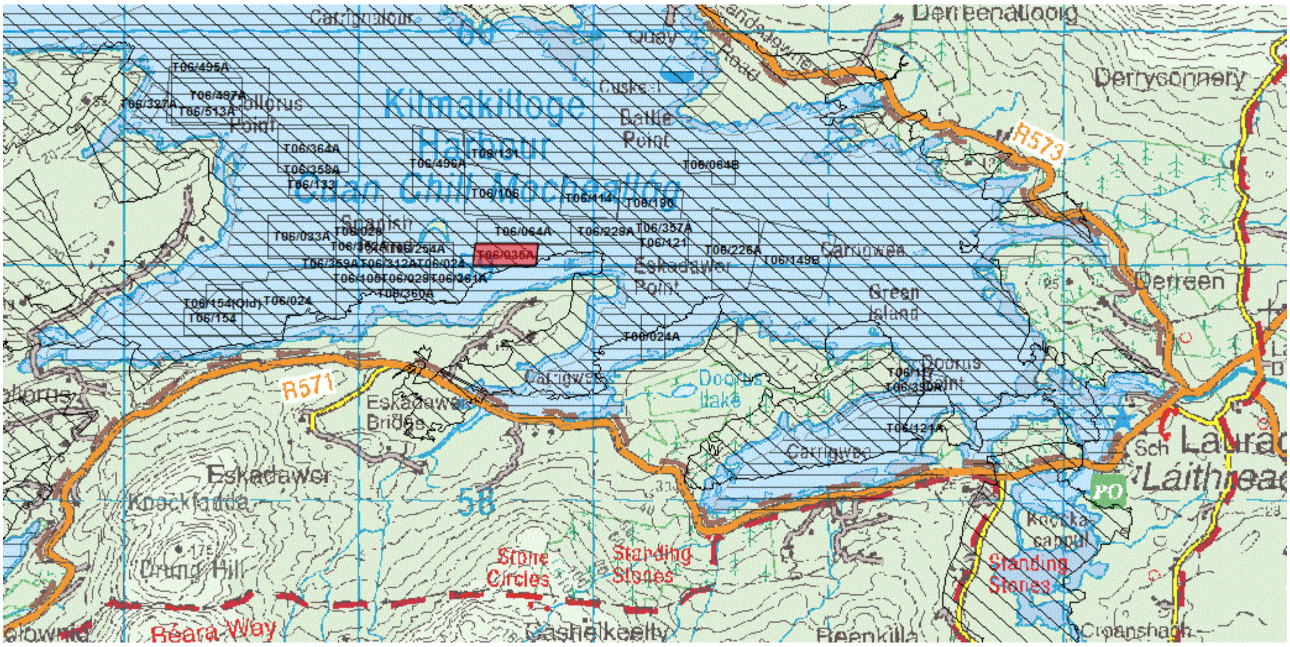
Dr. Terry McMahon
Section Manager, Marine Environment and Food Safety Services,
The Marine Institute.



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A two-way nested high resolution coastal simulation in a tidally dominated area: Preliminary results

I. Mamoutos (1), T. Dabrowski (1) and K. Lyons (1) and G. McCoy (2)

(1) Marine Institute, Rinville, Oranmore, Co. Galway, Ireland. Ioannis.Mamoutos@Marine.ie
(2) Bord Iascagh Mhara, Crofron Road, Dun Laoghaire, Co. Dublin, Ireland

Abstract: Many coastal waterbodies along the Irish coast are tidally dominated Kenmare Bay, in the southwest part, is a typical example. Physical and biogeochemical processes are controlled almost exclusively by the tides. In this paper preliminary results from a fully 3D high resolution numerical simulation using state of the art modelling methods are presented. In particular a two-way nesting algorithm combined with a wetting and drying scheme is used to examine the impact of tides on an even smaller bay, namely Kilmakilloge Harbour. This bay is located along the southern shores of Kenmare bay and is of high economic importance due to intense aquaculture activity therein. To date, only the hydrodynamic component of the model was activated and the results are compared with observations to assess the model skill.

Keywords: Kenmare Bay, coastal modelling, two-way nesting, tidal mixing,

1. INTRODUCTION

The tidal range over the Celtic Seas region is considered to be one of the largest in the European shelf. The tidal waves of open Atlantic are generally small but they increase as they move eastwards across to the Irish shelf and are enhanced dramatically by the funnelling effect of bays and estuaries. Kenmare Bay, at the southwest coast Ireland, is a typical example with an average tidal range of around 2 meters. Almost all physical and biogeochemical processes are mainly controlled by the tides and in smaller scale by the rivers outflow.

In this work we have set up a fully two-way nested 3D hydrodynamic simulation to focus on an even smaller bay (Kilmakilloge) inside the Kenmare and to investigate the impact of tides in it. Kilmakilloge is an economically important region due to intensive aquaculture activity. At the current stage only the hydrodynamic component of model is activated and the output data is under validation, but in the near future a set-up of a fully coupled physical – biogeochemical – shellfish model is planned.

2. MATERIAL AND METHODS

2.1. Hydrographic observations

The hydrographic observations presented in this paper were obtained by Ireland's Seafood Development Agency (BIM) in the framework of monitoring the Kilmakilloge Harbour, through the installation of three loggers located in stations A, B and C (Fig. 1b). Data from these sites covers the period from February 15th 2017 to 4th of April 2017 and surpass the period of our initial hindcast for a few days. Loggers were set to record salinity and *in situ* temperature every one hour at 1 meter depth for all three stations, 4 meter at station A and 6.5 meters at station B. Unfortunately no data was recovered from the bottom station (6.5 meters) at due to logger fault.

2.2. Model description

The numerical simulation was performed using the Regional Ocean Modelling System (ROMS) (Shchepetkin and McWilliams, 2003, 2005), a free-surface, terrain-following, primitive equations ocean model widely used by the scientific community for a diverse range of applications (Haidvogel *et al.*, 2000; Wilkin *et al.*, 2005). A rectangular grid covering the Kenmare Bay with 120 meters resolution was developed (Fig. 1a) and a second one with 40 meters resolution for Kilmakilloge hereafter named the donor and the receiver grid respectively. The vertical resolution for both grids is

15 sigma levels. High resolution bathymetric data was provided by the INFOMAR Programme (www.infomar.ie), Ireland's Integrated Mapping for the Sustainable Development of Ireland's Marine Resource. A minimal smooth over the bathymetry was conducted using a linear programming method (Sikiric *et al.*, 2009).

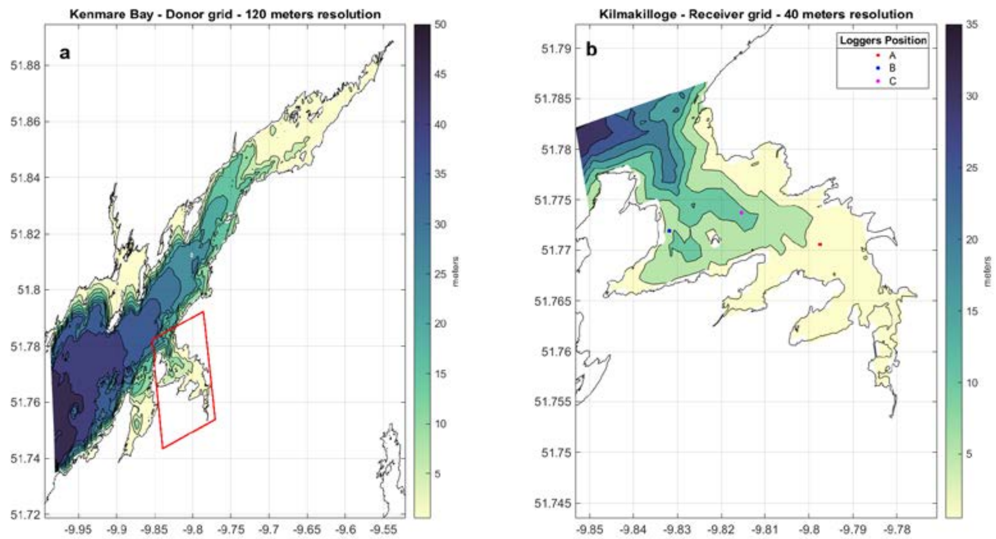

Fig. 1. (a) Bathymetry in meters of Kenmare Bay and contact points of the receiver grid (red), (b) Kilmakiloge Harbour's bathymetry in meters and the position of the temperature and salinity loggers.

From the available turbulence mixing schemes we adopted k – ε parameterization, as implemented through the GLS scheme (Umlauf and Burchard, 2003; Warner *et al.*, 2005). The model's default background values were used for vertical viscosity and diffusivity. For the horizontal diffusion and viscosity a harmonic Laplacian operator was selected with very weak value for stability reasons. A logarithmic drag law was used for the parameterization of bottom stress. The default third – order upstream advection scheme was used for velocity, TS_MPDATA (Smolarkiewicz, 1998) was used for the horizontal and vertical advection of tracers and a wetting and drying cell option. The initial and boundary conditions are provided from Marine's Institute high resolution coastal operational model of Bantry Bay (Dabrowski *et al.*, 2016). The boundary condition temporal resolution is 10 minutes and includes the tidal signal. Atmospheric forcing fields from ECMWF were used with spatial resolution 0.125 × 0.125 degrees and three-hour time step. Four major rivers are included and come from E-HYPE (SMHI – Swedish Meteorological and Hydrological Institute) and OPW (Office of Public Works, Ireland). The model was run from 8th of February to 26th of March 2017.

3. RESULTS

The correlation coefficient, standard deviation and centred root mean square differences for in situ temperature of the water at the three BIM stations – for 1, 4 and 6.5 meters – are presented on Taylor diagrams in Fig. 2. Fig 2 presents the comparison, in terms of statistics, between the observed and simulated values of in situ temperature at 1 m depth – left panel – and for 4 and 6.5 m depth – right panel – for all BIM stations inside Kilmakilloge Harbour.

Overall, the model presents good skill and a correlation coefficient for temperature is close 0.8 for all stations and depths. As regards salinity (not shown here), the model's skill is significantly worse with correlation coefficient values close to zero and having positive and negative signs. It is worth noting though, that, especially for salinity, the further we move from river mouth the better the score we obtain.

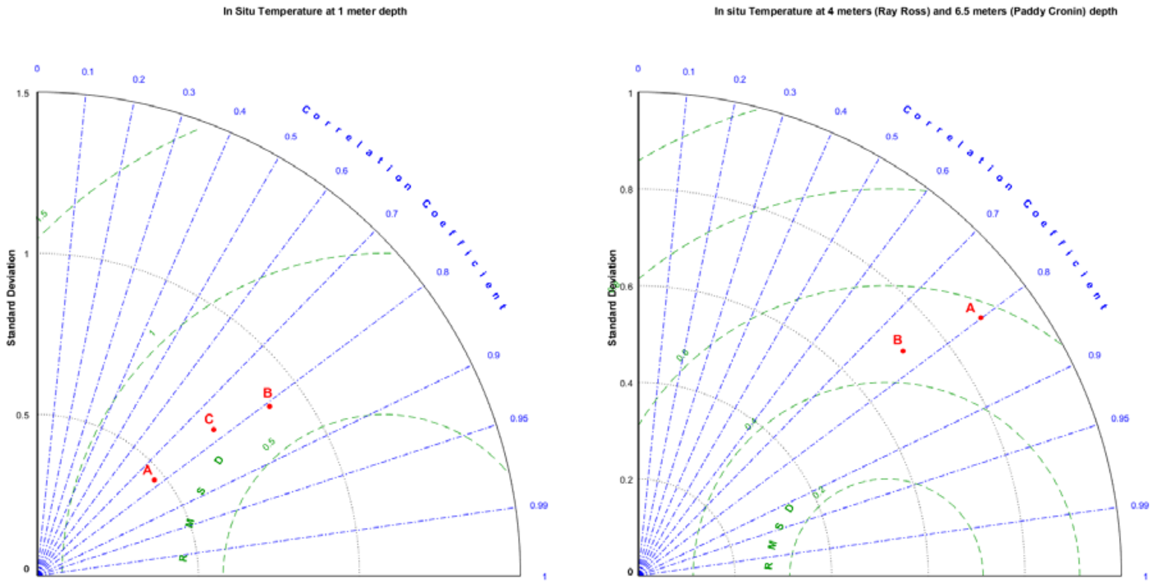

Fig. 2. Statistical comparison between observed and simulated values of in situ temperature in all available depths for all stations in Kilmakilloge Harbour.

Not having any tidal records for Kilmakilloge Harbour we decided to use a coherence diagram to validate our model in terms of tides. Fig.3 (a) presents a coherence diagram and (b) the phase difference in degrees between observed and simulated data in order to investigate the ability of our model to reproduce the tidal signal correctly. The recorded and simulated salinity is shown for station B. The results for the other stations are similar. From the below figure we conclude that the model is able to represent in an adequate way the dominant tidal harmonics, the semi-diurnal and the shallow water quarter diurnal, having high coherence scores for both (0.8) for 99% confidence level. The phase difference for the semi-diurnal constituent is close to zero and for the shallow water quarter diurnal almost 45 degrees.

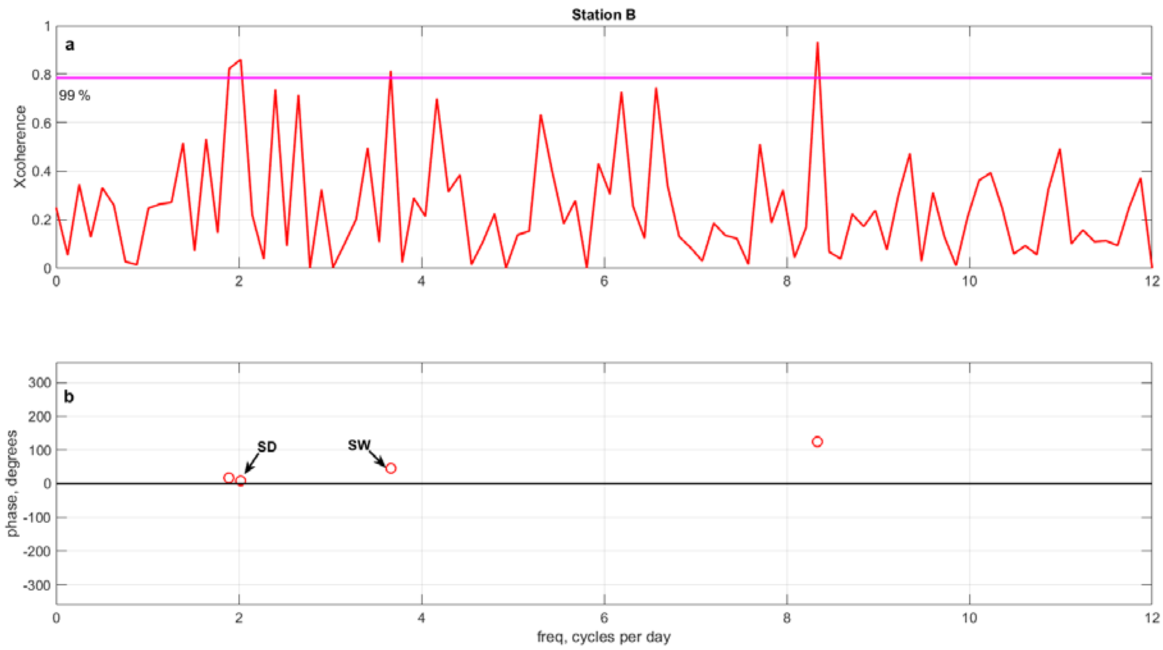

Fig. 3.(a) Coherence diagram and (b) phase difference in degrees for station B in Kilmakilloge Harbour. SD denotes semi-diurnal and SW shallow water quarter semi-diurnal constituents, respectively.

4. CONCLUSIONS/DISCUSSION

In this work we present the preliminary results from a high resolution two-way nested simulation for Kenmare Bay and Kilmakilloge Harbour for assessing the model behaviour, exploiting the observed hydrographic data as a benchmark for our future hindcasts which will include a fully coupled physical – biogeochemical – shellfish setup. Our preliminary results suggest that the model reproduces the dominant mechanism – tidal mixing – in an adequate way (Fig. 3) for the area of interest and also that there is a good match – especially for temperature – between the observed and simulated data. One possible source for the difference in shallow water quarter semi-diurnal constituent between model and observation can be the use of the default value for model's bottom drag coefficient.

The lack of realistic data for the rivers outflow inside Kilmakilloge Harbour is a significant source of errors and is aliasing for simulated temperature and salinity fields. From our analysis it is clear that the main problem is the riverine outflow and that the closer we move to the river mouth the lower the value and skill scores we obtain for the model. One other possible issue, although its contribution may be of less importance compared to the absence of realistic data for rivers, could be the choice of initial condition for the model. MI's Bantry Bay operational model does not include any rivers inside the Kenmare Harbour. But again, we assume that this does not have the same impact on our results because the model converges relatively quickly after a few days.

Thus we arrive to the conclusion that the model in its current form overestimates mixing inside Kilmakilloge Harbour. Our first aim for future experiments is to use other sources for freshwater discharges once they are available and second to explore the different parameterizations of GLS vertical mixing scheme before we setup the coupled physical – biogeochemical – shellfish simulation.

Acknowledgements

This work has been performed and supported in the framework of the project « Tools for Assessment and Planning of Aquaculture Sustainability (TAPAS) », funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 678396.

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Date: 07 May 2019

Deirdre Fitzpatrick
Aquaculture and Foreshore Management Division
Department of Agriculture, Food and the Marine
Clogheen,
Clonakilty
Co. Cork.

Advice on Aquaculture Licence Application

Applicant	**Kieran Lyons**
Application type	**New**
Site Reference No	**T06/364A**
Species	**Mussels (M. edulis) - longlines**
Site Status	**Located within the Kenmare River SAC (Site Code 002158)** **Located within the Kenmare River / Sneem/ Ardgroom designated Shellfish Growing Waters Area.**

Dear Deirdre

This is an application for aquaculture licence to cultivate mussels (M. edulis) using longlines at Site T06/364A in Kenmare Bay, Co. Kerry. The area of foreshore at Site T06/364A is circa 6.0Ha

No chemicals or hazardous substances will be used during the production process.

The cultivation of shellfish at this site will produce faeces and pseudofaeces. Any impact will be limited to the area of the site. The build-up of excess organic matter beyond the footprint of the sites is not considered likely.

Considering the location, nature and scale of the proposed aquaculture activity, and in deference to our remit under the Marine Institute Act, and the considerations implicit to Sections 61(e and f) of the Fisheries (Amendment) Act, 1997 the Marine Institute is of the view that there will be no significant impacts on the marine environment and that the quality status of the area will not be adversely impacted

Site T06/364A is located within the Kenmare River / Sneem/ Ardgroom designated Shellfish Growing Water Area.

Under Annex II of EU Regulation 854/2004 mussels in the Kilmakillogue area currently have a seasonal "A" Classification from 1st December – 1st May and revert to a "B" Classification at all other times

Site T06/364A is located within the Kenmare River SAC (Site Code 002158)

We note the findings of the Appropriate Assessment report[1] and the Department's draft Natura conclusion statement[2] in regard to the impacts on the Conservation Objectives within the Kenmare River SAC.

1 https://www.agriculture.gov.ie/media/migration/seafood/aquacultureforeshoremanagement/aquaculturelicensing/aquacultureforeshorelicenceapplications/cork/2019/AppropAssessofAquacultandFisheriesRiskAssessinKenmareRiverSAC270319.pdf

2 https://www.agriculture.gov.ie/media/migration/seafood/aquacultureforeshoremanagement/aquaculturelicensing/appropriateassessmentconclusionstatement/DRAFTAACONCLUSIONSTATEMENT260319.pdf

In making the final determination with respect to this application it is recommended that DAFM take full account of the conclusions and recommendations of the Appropriate Assessment report and the proposed mitigation measures set out in the Department's Draft Natura Conclusion Statement.

In order to be able to assess and manage the potential risk of the introduction of invasive non-native species the MI recommends that the initial source of seed and other sources which may be used at any point in the future should be approved by the Minister. This approval should be a specific condition of any licence that may issue. It should be noted that the control of alien species is a separate issue to the control of diseases in the context of the current Fish Health legislation.

Notwithstanding the recommendation outlined above, and in the event that an Aquaculture Licence is granted, the movement of stock in and out of the site should follow best practice guidelines as they relate to the risk of introduction of invasive non-native species (e.g. Invasive Species Ireland). In this regard it is recommended that, prior to the commencement of operations at the site, the applicant be required to draw up a contingency plan, for the approval of DAFM, which shall identify, *inter alia*, methods for the removal from the environment of any invasive non-native species introduced as a result of operations at this site. If such an event occurs, the contingency plan shall be implemented immediately.

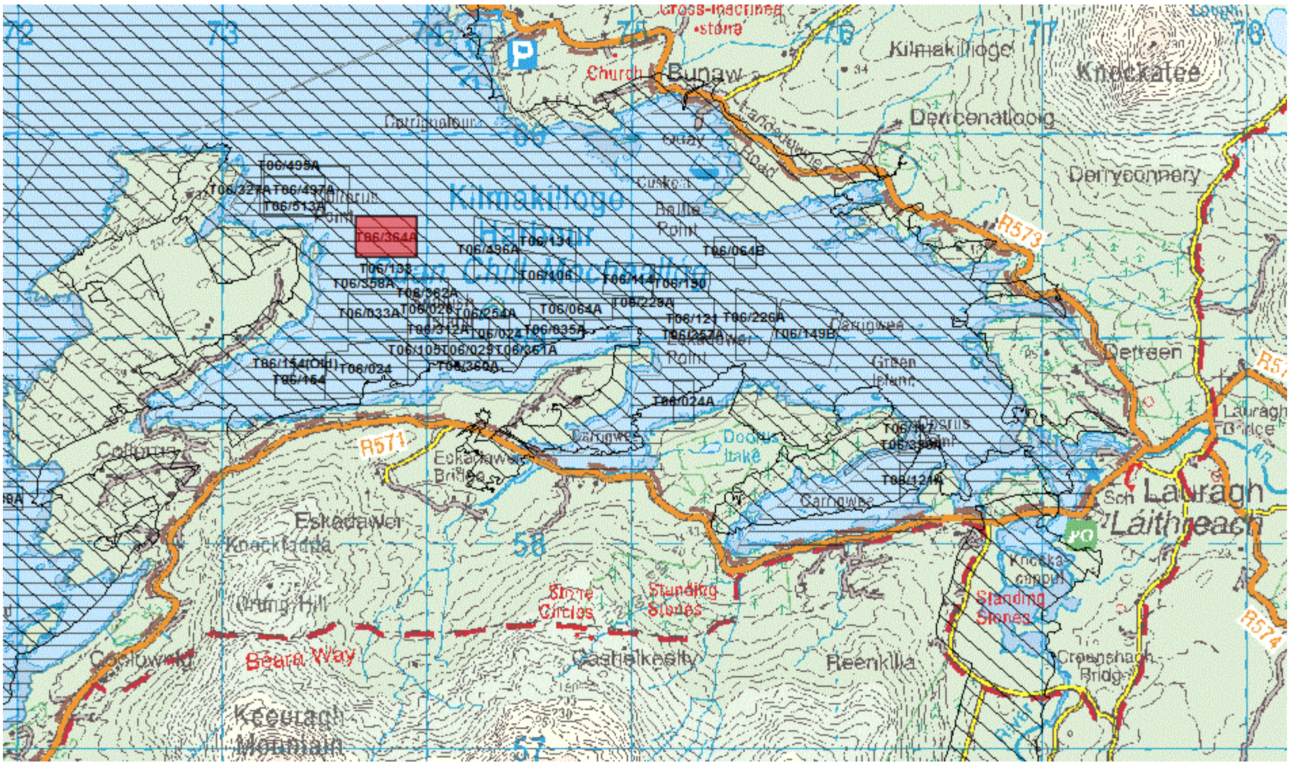
In the event that invasive non-native species are introduced into a site as a result of aquaculture activity the impacts may be bay -wide and thus affect other aquaculture operators in the bay. In this regard, therefore, the Marine Institute considers that the CLAMS process may be a useful and appropriate vehicle for the development and implementation of alien species management and control plans.

It is statutory requirement that a Fish Health Authorisation as required under Council Directive 2006/88/EC be in place prior to the commencement of the aquaculture activities proposed.

Kind regards,

____

Dr. Terry McMahon
Section Manager, Marine Environment and Food Safety Services,
The Marine Institute.



☑ Shellfish Waters Directive Area

☑ Aquaculture Site

☑ Special Area of Conservation

☑ Special Protection Areas

Rinville,
Oranmore,
Co. Galway
Tel: 091 387200
Date: 07 May 2019

Maria Naughton
Aquaculture and Foreshore Management Division
Department of Agriculture, Food and the Marine
Clogheen,
Clonakilty
Co. Cork.

Advice on Aquaculture Licence Application

Applicant	**Kush Seafarms Ltd**
Application type	**New**
Site Reference No	**T06/513A**
Species	**Mussels (M. edulis) - longlines**
Site Status	**Located within the Kenmare River SAC (Site Code 002158)** **Located within the Kenmare River / Sneem/ Ardgroom designated Shellfish Growing Waters Area.**

Dear Maria

This is an application for an aquaculture licence to cultivate mussels (M. edulis) using longlines at Site T06/513A in Kenmare Bay, Co. Kerry. The area of foreshore at Site T06/513A is circa 6.00 Ha

No chemicals or hazardous substances will be used during the production process.

The cultivation of shellfish at this site will produce faeces and pseudofaeces. Any impact will be limited to the area of the site. The build-up of excess organic matter beyond the footprint of the sites is not considered likely.

Considering the location, nature and scale of the proposed aquaculture activity, and in deference to our remit under the Marine Institute Act, and the considerations implicit to Sections 61(e and f) of the Fisheries (Amendment) Act, 1997 the Marine Institute is of the view that there will be no significant impacts on the marine environment and that the quality status of the area will not be adversely impacted

Site T06/513A is located within the Kenmare River / Sneem/ Ardgroom designated Shellfish Growing Water Area.

Under Annex II of EU Regulation 854/2004 mussels in the Kilmakillogue area currently have a seasonal "A" Classification from 1st December – 1st May and revert to a "B" Classification at all other times

Site T06/513A is located within the Kenmare River SAC (Site Code 002158)

We note the findings of the Appropriate Assessment report[1] and the Department's draft Natura conclusion statement[2] in regard to the impacts on the Conservation Objectives within the Kenmare River SAC.

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In making the final determination with respect to this application it is recommended that DAFM take full account of the conclusions and recommendations of the Appropriate Assessment report and the proposed mitigation measures set out in the Department's Draft Natura Conclusion Statement.

In order to be able to assess and manage the potential risk of the introduction of invasive non-native species the MI recommends that the initial source of seed and other sources which may be used at any point in the future should be approved by the Minister. This approval should be a specific condition of any licence that may issue. It should be noted that the control of alien species is a separate issue to the control of diseases in the context of the current Fish Health legislation.

Notwithstanding the recommendation outlined above, and in the event that an Aquaculture Licence is granted, the movement of stock in and out of the site should follow best practice guidelines as they relate to the risk of introduction of invasive non-native species (e.g. Invasive Species Ireland). In this regard it is recommended that, prior to the commencement of operations at the site, the applicant be required to draw up a contingency plan, for the approval of DAFM, which shall identify, *inter alia*, methods for the removal from the environment of any invasive non-native species introduced as a result of operations at this site. If such an event occurs, the contingency plan shall be implemented immediately.

In the event that invasive non-native species are introduced into a site as a result of aquaculture activity the impacts may be bay -wide and thus affect other aquaculture operators in the bay. In this regard, therefore, the Marine Institute considers that the CLAMS process may be a useful and appropriate vehicle for the development and implementation of alien species management and control plans.

It is statutory requirement that a Fish Health Authorisation as required under Council Directive 2006/88/EC be in place prior to the commencement of the aquaculture activities proposed.

Kind regards,

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Dr. Terry McMahon
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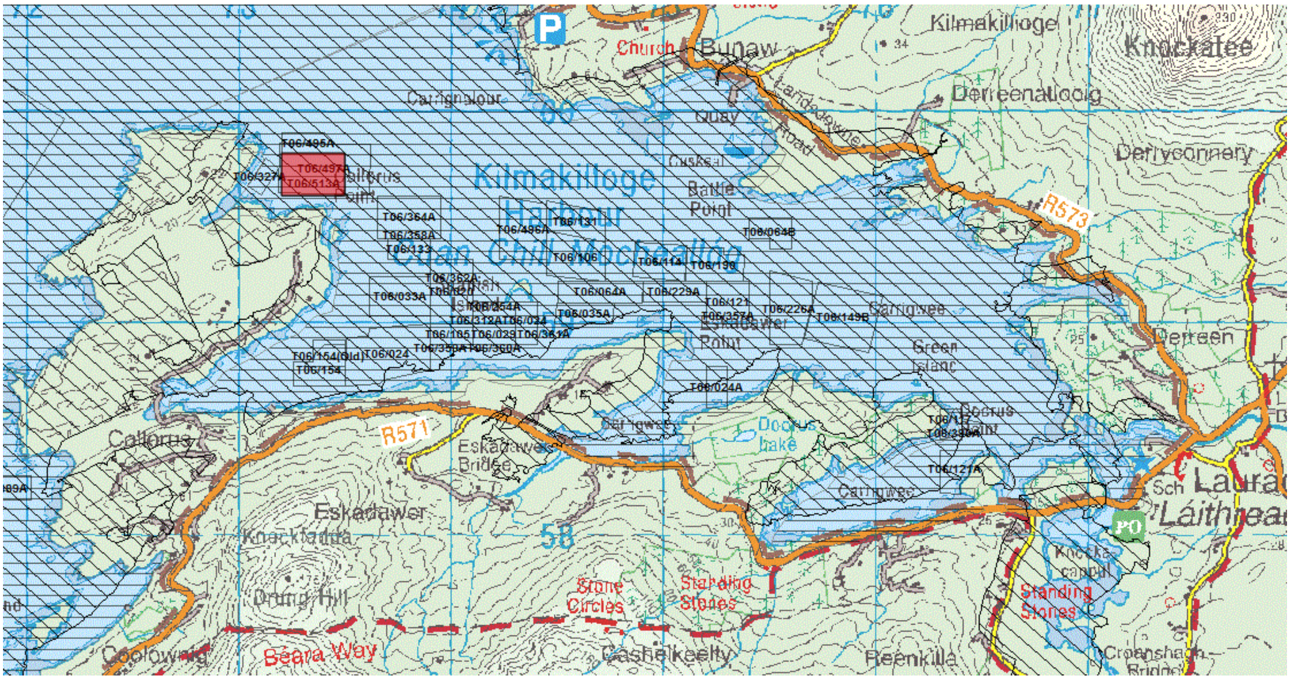

☑ Shellfish Waters Directive Area

☑ Aquaculture Site

☑ Special Area of Conservation

☑ Special Protection Areas

Rinville,
Oranmore,
Co. Galway
Tel: 091 387200
Date: 07 May 2019

Maria Naughton
Aquaculture and Foreshore Management Division
Department of Agriculture, Food and the Marine
Clogheen,
Clonakilty
Co. Cork.

Advice on Aquaculture Licence Application

Applicant	**Kush Seafarms Ltd**
Application type	**New**
Site Reference No	**T06/360A**
Species	**Mussels (M. edulis) - longlines**
Site Status	**Located within the Kenmare River SAC (Site Code 002158)** **Located within the Kenmare River / Sneem/ Ardgroom designated Shellfish Growing Waters Area.**

Dear Maria

This is an application for an aquaculture licence to cultivate mussels (M. edulis) using longlines at Site T06/360A in Kenmare Bay, Co. Kerry. The area of foreshore at Site T06/360A is circa 2.00 Ha

No chemicals or hazardous substances will be used during the production process.

The cultivation of shellfish at this site will produce faeces and pseudofaeces. Any impact will be limited to the area of the site. The build-up of excess organic matter beyond the footprint of the sites is not considered likely.

Considering the location, nature and scale of the proposed aquaculture activity, and in deference to our remit under the Marine Institute Act, and the considerations implicit to Sections 61(e and f) of the Fisheries (Amendment) Act, 1997 the Marine Institute is of the view that there will be no significant impacts on the marine environment and that the quality status of the area will not be adversely impacted

Site T06/360A is located within the Kenmare River / Sneem/ Ardgroom designated Shellfish Growing Water Area.

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Site T06/360A is located within the Kenmare River SAC (Site Code 002158)

We note the findings of the Appropriate Assessment report[1] and the Department's draft Natura conclusion statement[2] in regard to the impacts on the Conservation Objectives within the Kenmare River SAC.

[1] https://www.agriculture.gov.ie/media/migration/seafood/aquacultureforeshoremanagement/aquaculturelicensing/aquacultureforeshorelicenceapplications/cork/2019/AppropAssessofAquacultandFisheriesRiskAssessinKenmareRiverSAC270319.pdf

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In making the final determination with respect to this application it is recommended that DAFM take full account of the conclusions and recommendations of the Appropriate Assessment report and the proposed mitigation measures set out in the Department's Draft Natura Conclusion Statement.

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It is statutory requirement that a Fish Health Authorisation as required under Council Directive 2006/88/EC be in place prior to the commencement of the aquaculture activities proposed.

Kind regards,

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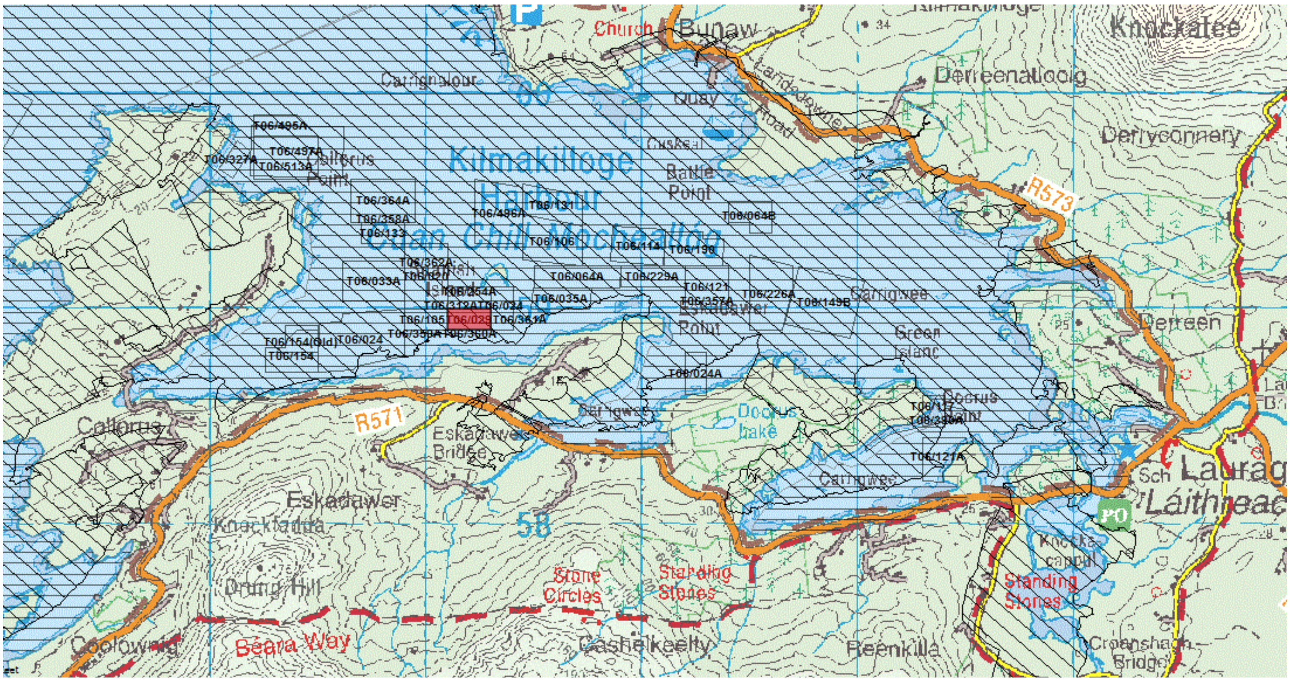


☑ Shellfish Waters Directive Area

☑ Aquaculture Site

☑ Special Area of Conservation

☑ Special Protection Areas

Short report on

Water Framework Directive Benthic Macro-invertebrate sampling analysis and results in Kilmackillogue Harbour, Co. Kerry (IE_SW_190_0200)

Louise Healy, Jack O'Carroll

Benthos Ecology

Marine Environment and Food Safety Service Area

Kilmakillogue Harbour- Infaunal Quality Index data

A requirement of the Water Framework Directive (2000/60/EC) is that benthic macro-invertebrates must be sampled from nominated coastal and transitional waters at least twice within a river basin cycle (6 years) in order to classify these waterbodies.

The Marine Institute is responsible for the Benthic Macro-invertebrates monitoring in Ireland's Coastal and transitional waters. Samples were collected in areas of soft sediment (where possible) using a 0.1m^2 Day grab. All samples were sieved on a 1mm sieve as a sediment water suspension, all material retained on the sieve were placed in containers and fixed using an appropriate fixative solution. These samples were then sorted in the laboratory and identified to the lowest practical taxonomic level. Also at each sampling point a sediment sample is taken and returned to the laboratory for particle size analysis (PSA).

The Infaunal Quality Index (IQI) multimetric (developed by the UK-Ireland Benthic Invertebrate subgroup of the UK-Ireland Marine Task Team) is used to evaluate the marine benthic macro-invertebrate ecological quality element of the Water Framework Directive. It describes the ecological status based on soft sediment infaunal communities.

The IQI Calculation workbook is used to obtain an IQI score. Species number, sampling method, Particle Size Analysis (PSA) and salinity regime are required in order for the workbook to successfully calculate an IQI score.

IQI is calculated by measuring the number of taxa (S), AZTI Marine Biotic Index (AMBI) and Simpson Evenness (1-λ'). The weighting of each can be seen below.

Weighting	Value
S^0.1	**0.54**
1-(AMBI/7)	**0.38**
1-Lambda'	**0.08**

AMBI is based on a measure of species sensitivity. Species are distributed into one of five ecological groups, ranging from species very sensitive to disturbance to first- order opportunistic species. The AMBI score is then calculated as a weighted average of the sensitivity scores. A classification is then given of, normal, slightly polluted, moderately polluted, highly polluted or very highly polluted.

Simpson's Evenness Index is a measure of the evenness of the abundance distribution of different taxa within an assemblage. Areas dominated by few species are usually characteristic of disturbed areas, while areas with a higher diversity are associated with areas of low disturbance. The index ranges from zero to one with higher values corresponding to lower diversity.

The IQI compares observed values against values to be expected under undisturbed conditions.

$$\mathrm{IQI} = \frac{\left(\left(0.38 \times \left(\frac{(1-\mathrm{AMB}I/7)}{(1-\mathrm{AMBI}_{\mathrm{Ref}}/7)}\right)\right) + \left(0.08 \times \left(\frac{(1-\lambda')}{(1-\lambda')_{\mathrm{Ref}}}\right)\right) + \left(0.54 \times \left(\frac{S}{S_{\mathrm{Ref}}}\right)^{0.1}\right) - 0.4\right)}{0.6}$$

Each metric is normalised to a maximum value expected for that metric. Max parameters relate to the reference conditions for that metric based on expert judgement and best available historic data as stated in Annex V 1.3 (v) of the directive. The IQI ranges from zero to one. Those values closest to one indicate that benthic communities are close to their natural state.

As required by the Water Framework Directive the IQI range has been divided into five groups so as to determine biological status.

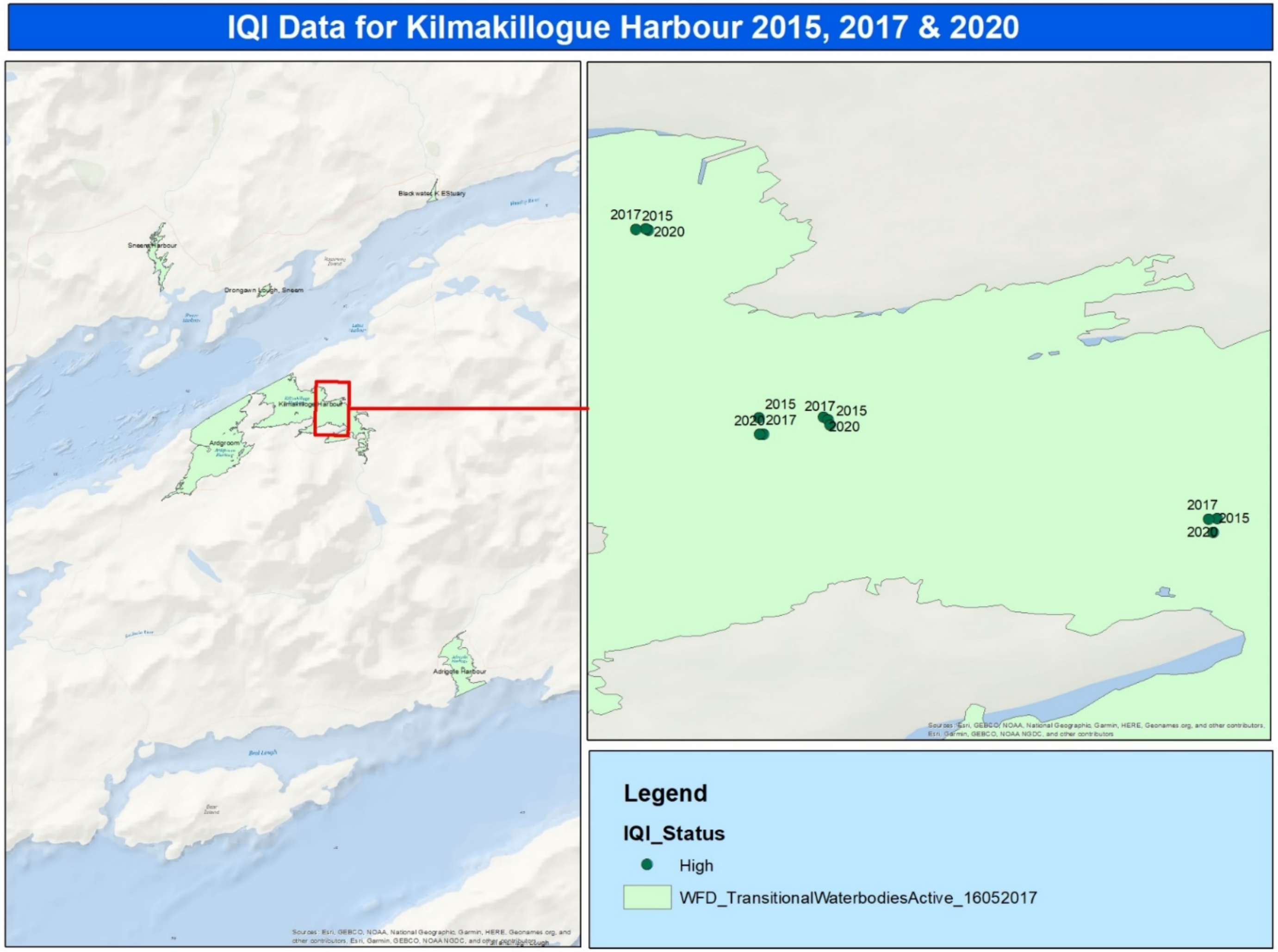
BAD/POOR	**0.24**
POOR/MODERATE	**0.44**
MODERATE/GOOD	**0.64**
GOOD/HIGH	**0.75**

Table 1 below shows the IQI data for all stations sampled in Kilmakillogue Harbours as part of the benthic monitoring programe. The locations of these staions can be seen in figure 1. Further information on Kilmakillogue Harbour can be found on the EPA website: https://www.catchments.ie/data/#/waterbody/IE_SW_190_0200?_k=6ggi2t.

Table 1. Sample data from Kilmakillogue Harbour collected as part of the Water Framework Directive Benthic Monitoring programme 2015, 2017,2020.

Sample id	Date	Depth (m)	Salinity ppt	Latitude	Longitude	IQI score	IQI Status	Folk	%LOI
MIBE20-219	11/07/2020	13	14	51.7775	-9.8083	1.00	High	Gravelly Muddy Sand	0.95
MIBE20-220	11/07/2020	6	22	51.7722	-9.8033	0.93	High	Gravelly Muddy Sand	1.00
MIBE20-221	11/07/2020	9	25	51.7717	-9.8050	0.85	High	Slightly Gravelly Muddy Sand	0.68
MIBE20-222	11/07/2020	6.1	24	51.7693	-9.7922	0.87	High	Slightly Gravelly Muddy Sand	0.63
MIBE20-223	11/07/2020	6.2	21	51.7706	-9.8261	1.03	High	Gravelly Muddy Sand	1.07
MIBE17-321	05/08/2017	8	-	51.7775	-9.8084	0.82	High	Mud	4.96
MIBE17-322	05/08/2017	9	-	51.7721	-9.8032	0.90	High	Mud	17.31
MIBE17-323	05/08/2017	10	-	51.7717	-9.8051	0.89	High	Mud	4.77
MIBE17-324	05/08/2017	6	-	51.7693	-9.7925	0.92	High	Mud	11.27
MIBE17-325	05/08/2017	15	-	51.7704	-9.8265	0.81	High	Mud	17.98
MIBE15-129	09/09/2015	6.0	-	51.7775	-9.8086	0.89	High	Gravelly sand	0.58
MIBE15-130	09/09/2015	7.0	-	51.7722	-9.8052	0.81	High	Sand	1.92
MIBE15-131	09/09/2015	9.0	-	51.7720	-9.8032	0.78	High	Sand	0.58
MIBE15-132	09/09/2015	6.0	-	51.7689	-9.7924	0.82	High	Slightly gravelly sand	0.52
MIBE15-133	09/09/2015	14.0	-	51.7705	-9.8268	0.87	High	Slightly gravelly sand	0.62

Figure 1 :IQI Data for Kilmakillogue Harbour 2015, 2017 &2020



Report supporting Appropriate Assessment of Aquaculture and Fisheries Risk Assessment in Kenmare River SAC

(Site Code: 2158)

Marine Institute

Rinville

Oranmore, Co. Galway

Version: October, 2017

List of Figures

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1. Preface

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

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

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

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

2. Executive summary

2.1 The SAC

Kenmare River is designated as a Special Area of Conservation (SAC) under the Habitats Directive. The marine area is designated for the habitats Large Shallow Inlet and Bay, Reef and Submerged Caves. The bay supports a variety of sub-tidal and intertidal sedimentary and reef habitats including habitats that are sensitive to pressures, which might arise from fishing and aquaculture, such as Maërl (corraline algae), seagrass and kelp reefs. The area is also designated for and supports significant numbers of Harbour Seal and Otter. Conservation Objectives for these habitats and species were identified by NPWS (2013a) and relate to the requirement to maintain habitat distribution, structure and function, as defined by characterizing (dominant) species in these habitats. For designated species the objective is to maintain various attributes of the populations including population size, cohort structure and the distribution of the species in the Bay. Guidance on the conservation objectives is provided by NPWS (2013b).

2.2 Activities in the SAC

Aquaculture includes the production of shellfish and finfish. The main aquaculture activity is suspended long-line mussel (*Mytilus edulis*) culture. Oyster culture involves the culture of the Pacific oyster (*Crassostrea gigas*) on trestles in intertidal areas. Clam and Scallop culture are both licensed in the area but are not currently active. There are four finfish (*Salmo salar*) farm sites currently active within the SAC.

The profile of the aquaculture industry in the Kenmare River, used in this assessment, was prepared by BIM and is derived from the list of licence applications received by DAFM and provided to the Marine Institute for assessment in February 2014.

A range of fishing activities occur in Kenmare River including potting, dredging and trawling for shellfish, demersal fish and pelagic fish. Other activities include, intertidal seaweed harvesting as well as seal watching tourism activity.

2.3 The Appropriate Assessment Process

The function of an appropriate assessment and risk assessment is to determine if the ongoing and proposed aquaculture and fisheries activities are consistent with the Conservation Objectives for the Natura site or if such activities will lead to deterioration in the attributes of the habitats and species over time and in relation to the scale, frequency and intensity of the activities. NPWS (2013b) provide guidance on interpretation of the Conservation Objectives which are, in effect, management targets for habitats and species in the SAC. This guidance is scaled relative to the anticipated sensitivity of habitats and species to disturbance by the proposed activities. Some activities are deemed to be wholly inconsistent with long term maintenance of certain sensitive habitats while other habitats can tolerate a range of activities. For the practical purpose of management of sedimentary habitats a 15% threshold of overlap between a disturbing activity and a habitat is given in the NPWS guidance. Below this threshold disturbance is deemed to be non-significant. Disturbance is defined as that which leads to a change in the characterizing species of the habitat (which may also indicate change in structure and function). Such disturbance may be temporary or persistent in the sense that change in characterizing species may recover to pre-disturbed state or may persist and accumulate over time.

The appropriate assessment and risk assessment process is divided into a number of stages consisting of a preliminary risk identification, and subsequent assessment (allied with mitigation measures if necessary) which are covered in this report. The first stage of the process is an initial screening wherein activities which cannot have, because they do not spatially overlap with a given habitat or have a clear pathway for interaction, any impact on the conservation features and are therefore excluded from further consideration. The next phase is the Natura Impact Statement (NIS) where interactions (or risk of) are identified. Further to this, an assessment on the significance of the likely interactions between activities and conservation features is conducted. Mitigation measures (if necessary) will be introduced in situations where the risk of significant disturbance is identified. In situations where there is no obvious mitigation to reduce the risk of significant impact, it is advised that caution should be applied in licencing decisions. Overall the Appropriate Assessment is both the process and the assessment undertaken by the competent authority to effectively validate this Screening Report and/or NIS. It is important to note that the screening process is considered conservative, in that other activities which may overlap with habitats but which may have very benign effects are retained for full assessment. In the case or risk assessments consequence and likelihood of the consequence occurring are scored categorically as separate components of risk. Risk scores are used to indicate the requirement for mitigation.

2.4 Data Supports

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

2.5 Findings

Aquaculture and Habitats:

The appropriate assessment and risk assessment finds that the majority of activities, at the current and proposed or likely future scale and frequency of activity are consistent with the Conservation Objectives for the Annex 1 habitats. The following are the exceptions:

1. Within the Kenmare River SAC the culture (licensed) of Scallops (*Pecten maximus*) on the seabed overlaps with three keystone communities, *Zostera* dominated community, Maerl dominated community and *Pachycerianthus multiplicatus* community. This activity is deemed disturbing to such community types. As key contributors to biodiversity and being sensitive to

[1] NPWS Geodatabase Ver: September 2013 - http://www.npws.ie/mapsanddata/habitatspeciesdata/

disturbance these community types are afforded a high degree of protection and no overlap with a disturbing activity can be tolerated.

2. Maerl dominated community occurs in certain areas (Ardgroom and Killmakilloge Harbours) which are outside of the Qualifying Interests for which the Kenmare River SAC was designated but are still within the SAC boundary. Maerl, the characterising species of this community, is listed as an Annex V species and as it is within the SAC boundary it must be afforded protection. Suspended mussel culture in Ardgroom Harbour overlaps this community type and is considered disturbing. As a key contributor to biodiversity and being sensitive to disturbance this community types is afforded a high degree of protection and no overlap with a disturbing activity can be tolerated.

Aquaculture and Species:

- It is acknowledged in this assessment that the favourable conservation status of the Harbour seal (*Phoca vitulina*) has been achieved given current levels of aquaculture production within the SAC. On this basis, the current levels of licenced aquaculture (existing) are considered non-disturbing to harbour seal conservation features. The following is one exception:
    - Aquaculture activity (oyster farm) overlapping Harbour Seal moulting site in Coongar Harbour. It is recommended that the site boundaries be redrawn to exclude the harbour seal haul-out location.
- The aquaculture activities proposed do not pose a threat to the Otter or migrating salmon in the Kenmare River SAC.

Fisheries and Habitats:

- Pot fisheries may pose a high risk to sensitive habitats (Zostera and Maerl) in Kenmare Bay and a low-moderate risk (depending on level of activity) to kelp communities
- Depending on intensity of activity demersal trawling may impact muddy sand communities in outer Kenmare Bay
- Scallop dredging poses a risk to faunal reef communities in Kenmare Bay.

Fisheries and Species:

- Although there is a risk of by-catch of harbour seal in set net fisheries in outer Kenmare Bay and in midwater trawl fisheries in the inner Bay this is unlikely to impact the Harbour Seal population in Kenmare. Sprat fisheries occur sporadically in Kenmare Bay and may temporarily reduce prey availability for Harbour Seal. This is unlikely to have significant effects on the Harbour Seal population
- Otters may occur as by-catch in trammel nets and pots fished in shallow water (<5m depth). As pots are usually deployed in waters deeper than 5m the risk of by-catch is thought to be very low and insignificant to otter populations in Kenmare

3. Introduction

This document assesses the potential ecological interactions of aquaculture and fisheries activities within the Kenmare River SAC (site code 2158) on the Conservation Objectives (COs) of the site.
The information upon which this assessment is based is a list of applications and extant licences for aquaculture activities administered by the Department of Agriculture Food and Marine (DAFM) and forwarded to the Marine Institute as of August 2013; as well as aquaculture and fishery profiling information provided on behalf of the operators by Bord Iascaigh Mara. The spatial extent of aquaculture licences is derived from a database managed by the DAFM[2] and shared with the Marine Institute.

4. Conservation Objectives for Kenmare River SAC (002158)

The appropriate assessment of aquaculture in relation to the Conservation Objectives for Kenmare River SAC is based on Version 1.0 of the objectives (NPWS 2013a - Version 1 April 2013) and supporting documentation (NPWS 2013b - Version 1 March 2013). The spatial data for conservation features was provided by NPWS[3].

4.1 The SAC Extent

Kenmare River is a long and narrow south-west facing bay situated in the south west of Ireland. Kenmare River has an exceptional complement of marine and terrestrial habitats associated with exposed coasts and ultra-sheltered bays. Numerous islands and inlets along the length of the bay provide areas of additional shelter in which a variety of habitats occur. Kenmare River SAC is designated for the marine Annex I qualifying interests of Large hallow inlets and bays (1160), Reefs (1170) and Submerged or partially submerged seacaves (8330). The Annex I habitat Large shallow inlets and bays is a large physiographic feature that may wholly or partly incorporate other Annex I habitats including Reefs and Submerged Seacaves within its area. A number of coastal habitats can also be found in the SAC, including Fixed coastal dunes with herbaceous vegetation (grey dunes), Vegetated sea cliffs of the Atlantic and Baltic coasts and shifting dunes along the shoreline with *Ammophilia arenaria* ("white dunes"). The SAC is also considered an important site for the two mammal species Harbour Seal (*Phoca vitulina*) and the Otter (*Lutra lutra*). The extent of the SAC is shown in Figure 1 below.

4.2 Qualifying Interests (SAC)

The SAC is designated for the following habitats and species (NPWS 2013a), as listed in Annex I and Annex II of the Habitats Directive:

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[2] DAFM Aquaculture Database version Aquaculture: 11th Nov, 2013
[3] NPWS Geodatabase Ver: September 2013 - http://www.npws.ie/mapsanddata/habitatspeciesdata/

- 1014 Marsh Snail *Vertigo angustior*
- 1160 Large shallow inlets and bays
- 1170 Reefs
- 1220 Perennial vegetation of stony banks
- 1230 Vegetated sea cliffs of the Atlantic and Baltic coasts
- 1303 Lesser Horseshoe Bat *Rhinolophus hipposideros*
- 1330 Atlantic salt meadows (Glauco-Puccinellietalia maritimae)
- 1355 Otter *Lutra lutra*
- 1365 Harbour seal *Phoca vitulina*
- 1410 Mediterranean salt meadows (*Juncetalia maritimi*)
- 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes")
- 2130 Fixed coastal dunes with herbaceous vegetation (grey dunes)
- 4030 European dry heaths
- 6130 Calaminarian grasslands of the *Violetalia calaminariae*
- 8330 Submerged or partially submerged sea caves

Constituent communities and community complexes recorded within the qualifying interest Annex 1 habitats (i.e. 1160 - Large Shallow inlets and Bays, 1170 - Reefs) are listed in NPWS (2013b) and illustrated in Figure 2 and consist of:

- Intertidal mobile sand community complex
- *Zostera*-dominated community
- Maërl-dominated community
- *Pachycerianthus multiplicatus* community
- Muddy fine sands dominated by polychaetes and *Amphiura filiformis* community complex
- Fine to medium sand with crustaceans and polychaetes community complex
- Coarse sediment dominated by polychaetes community complex
- Shingle
- Intertidal reef community complex
- *Laminaria*-dominated community complex
- Subtidal reef with echinoderms and faunal turf community complex

The Kenmare River SAC is designated for the Harbour seal (*Phoca vitulina*) and has been the subject of annual monitoring surveys during the moulting season (August-September) from 2009-2011 (NPWS 2010, 2011, 2012). Recent estimates of harbour seal populations at the site (inner Kenmare River) are 310 in 2009, 324 in 2010, and 309 in 2011. Two sites located in outer Kenmare River, Illaunsillagh and Cove Harbour/West Cove, were also surveyed. Estimates of seal populations at these outer sites rose from 21 (2009) to 37 (2011) and from 31 (2010) to 50 (2011) respectively.

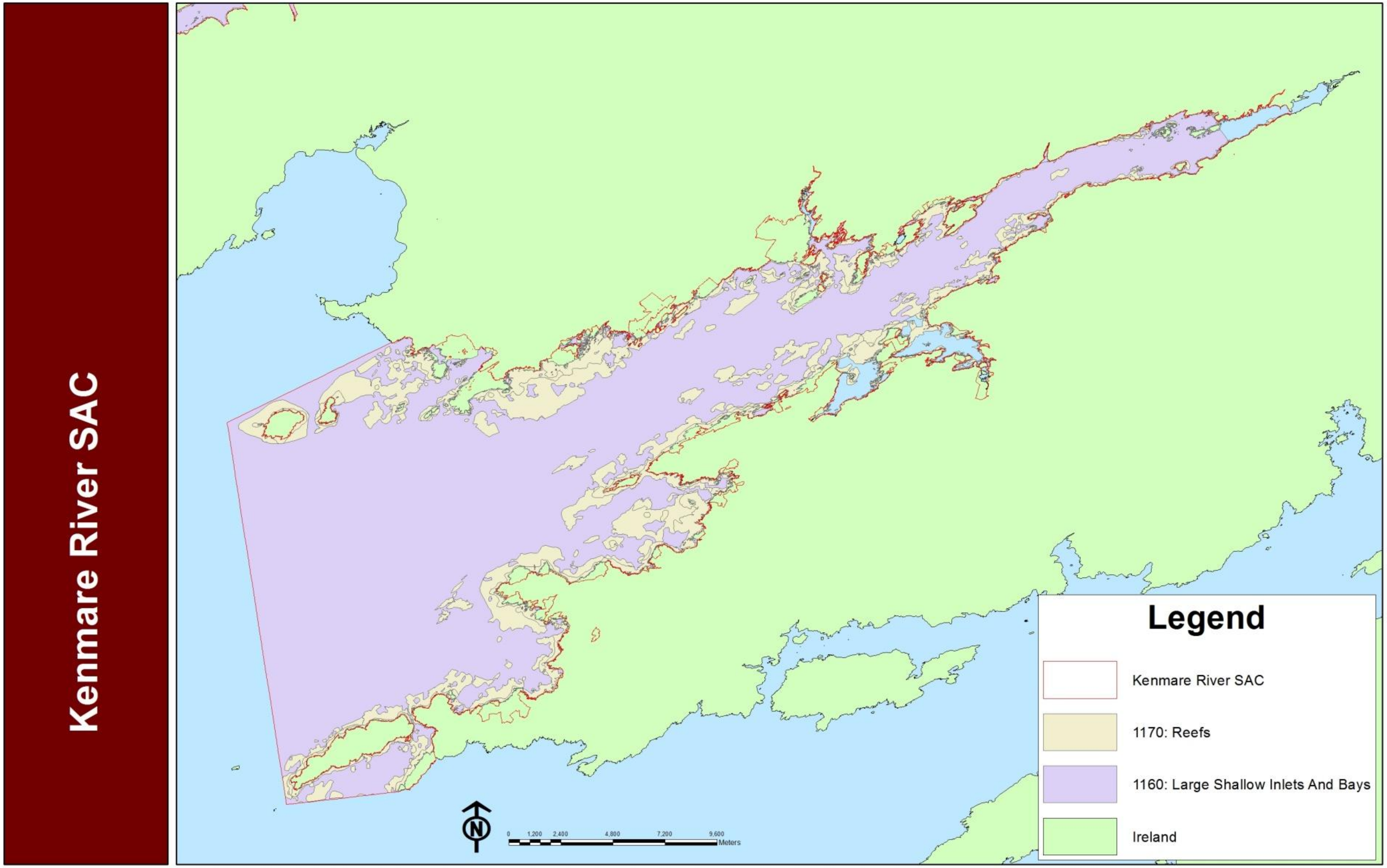

Figure 1: The extent of the Kenmare River SAC (Site Code 002158) and qualifying interest 1170 Reef and 1160 Large Shallow Inlet and Bay.

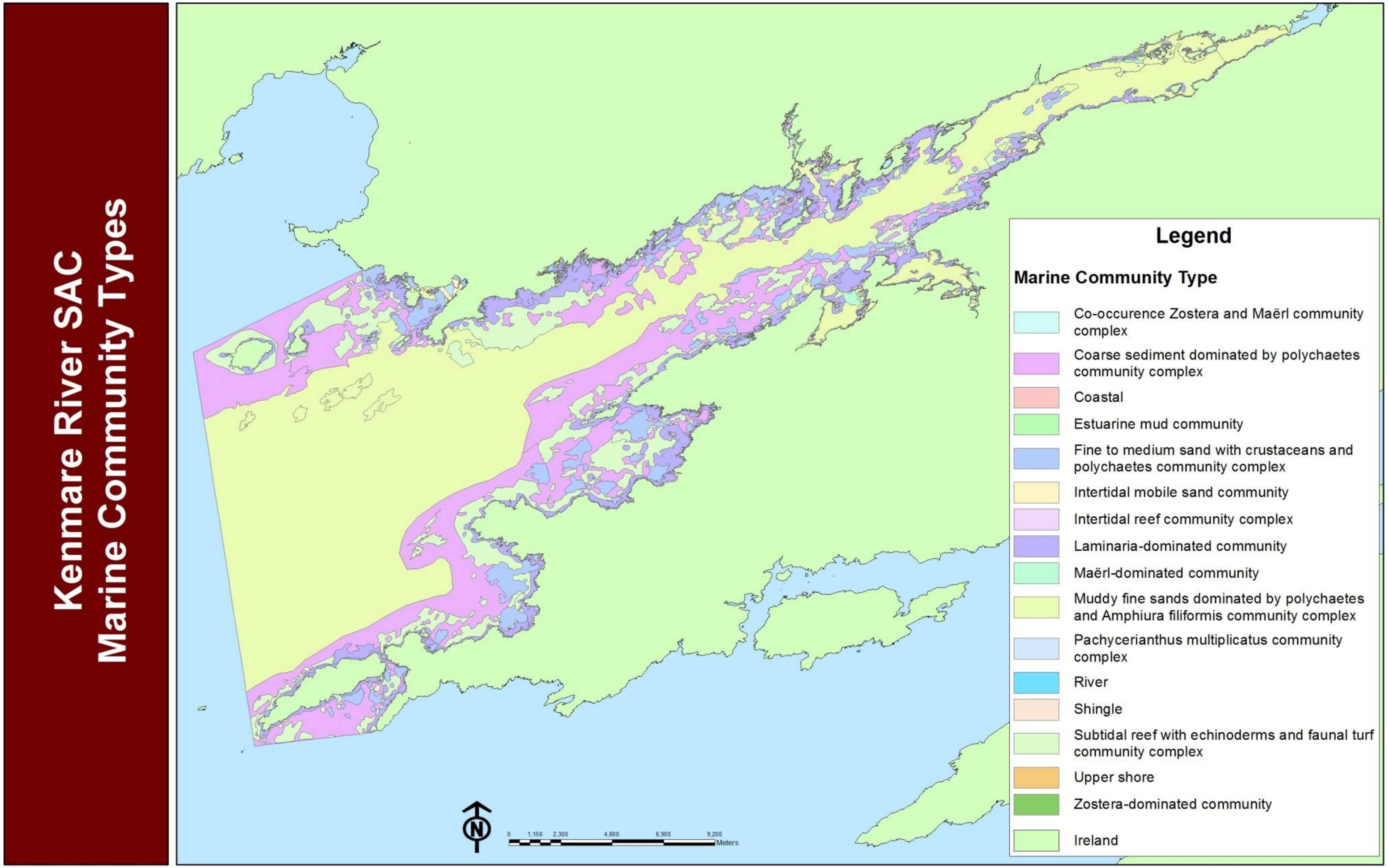

Figure 2. Principal benthic communities recorded within the qualifying interests Large shallow inlets and bays Reefs and Submerged or partially submerged sea caves within the Kenmare River SAC (Site Code 002158) (NPWS 2013a).

Based on recent reports (Cronin *et al*., 2004; Heardman *et al*., 2006; Cronin et al, 2008, NPWS 2010, 2011, 2012) the Kenmare River is deemed important both on a regional and on a national scale regarding its Harbour seal population.

A number of different locations have been identified within the SAC (NPWS 2013a) and are considered important to the overall welfare and health of the Harbour seal populations at the site. Figure 3 identifies these locations and distinguishes between breeding, moulting and resting sites. A site naming convention based upon designated periods in the life cycle have been identified by the competent authority, i.e. NPWS (NPWS 2011; 2013b). Important periods are the pupping season (May-July) and moulting season (August-September) and both periods and locations are considered important periods to the overall health of the population in the SAC and that any disturbance during these times should be kept to a minimum. Less information is known about resting period (October-April) and resting areas throughout the SAC. The resting locations provided in Figure 3 represent locations where seals have been observed, yet it must be noted that sheltered areas within the entire SAC are considered suitable habitat for resting seals (NPWS 2012, 2013a).

The Kenmare River SAC is designated for the Otter, *Lutra lutra*. The species is listed in Annex IV(a) of the habitats directive and is afforded strict protection. According to the NPWS (2009) although otter numbers have declined from 88% in 1980/81 to 70% in 2004/05, otters remain widespread in Ireland.

4.3 Conservation Objectives for Kenmare River SAC

The conservation objectives for the qualifying interests (SAC) were identified in NPWS (2013a). The natural condition of the designated features should be preserved with respect to their area, distribution, extent and community distribution. Habitat availability should be maintained for designated species and human disturbance should not adversely affect such species. The features, objectives and targets of each of the qualifying interests within the SAC are listed in Table 1 below.

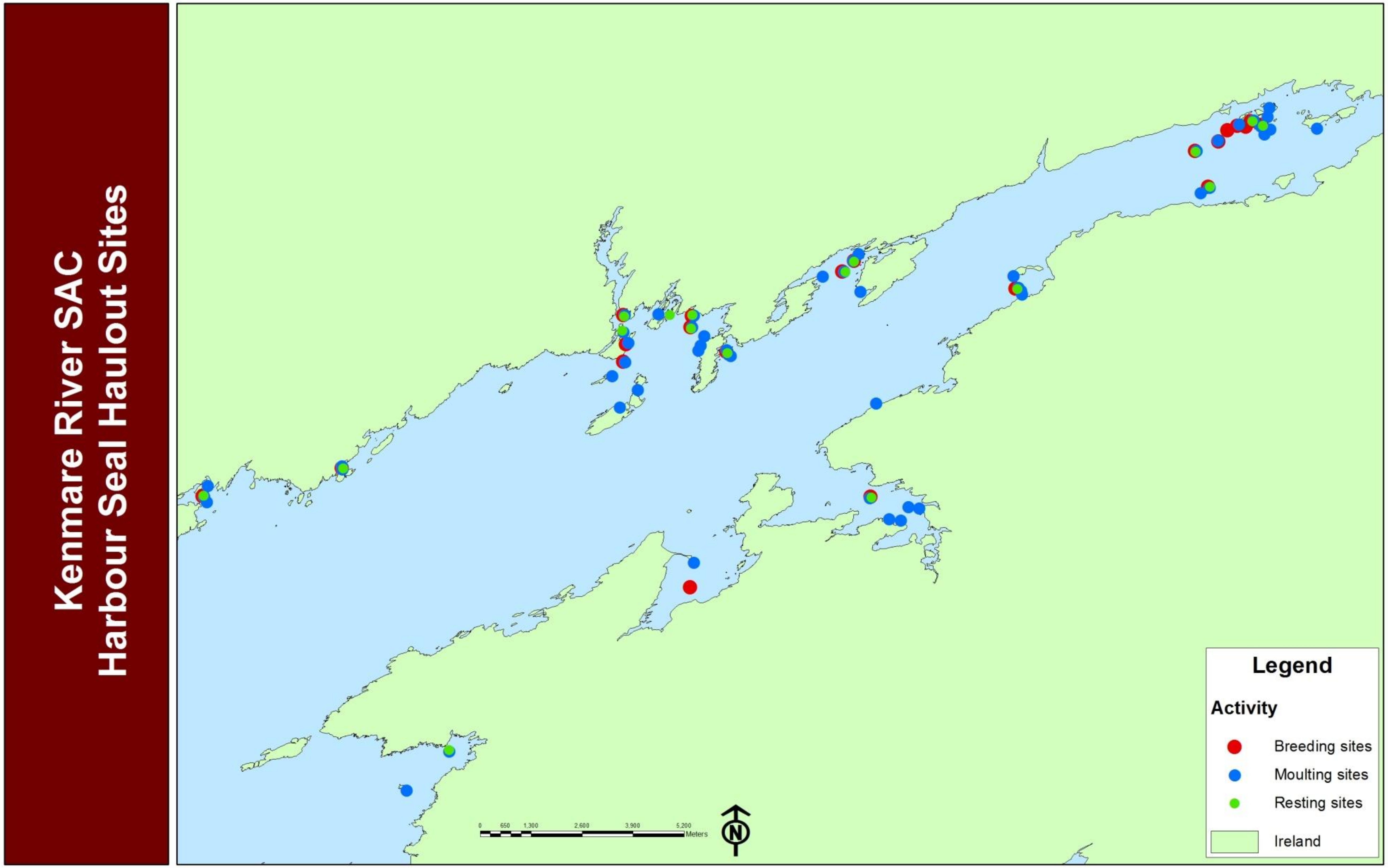

Figure 3 Harbour Seal (*Phoca vitulina*) locations in Kenmare River SAC (Site Code 002158).

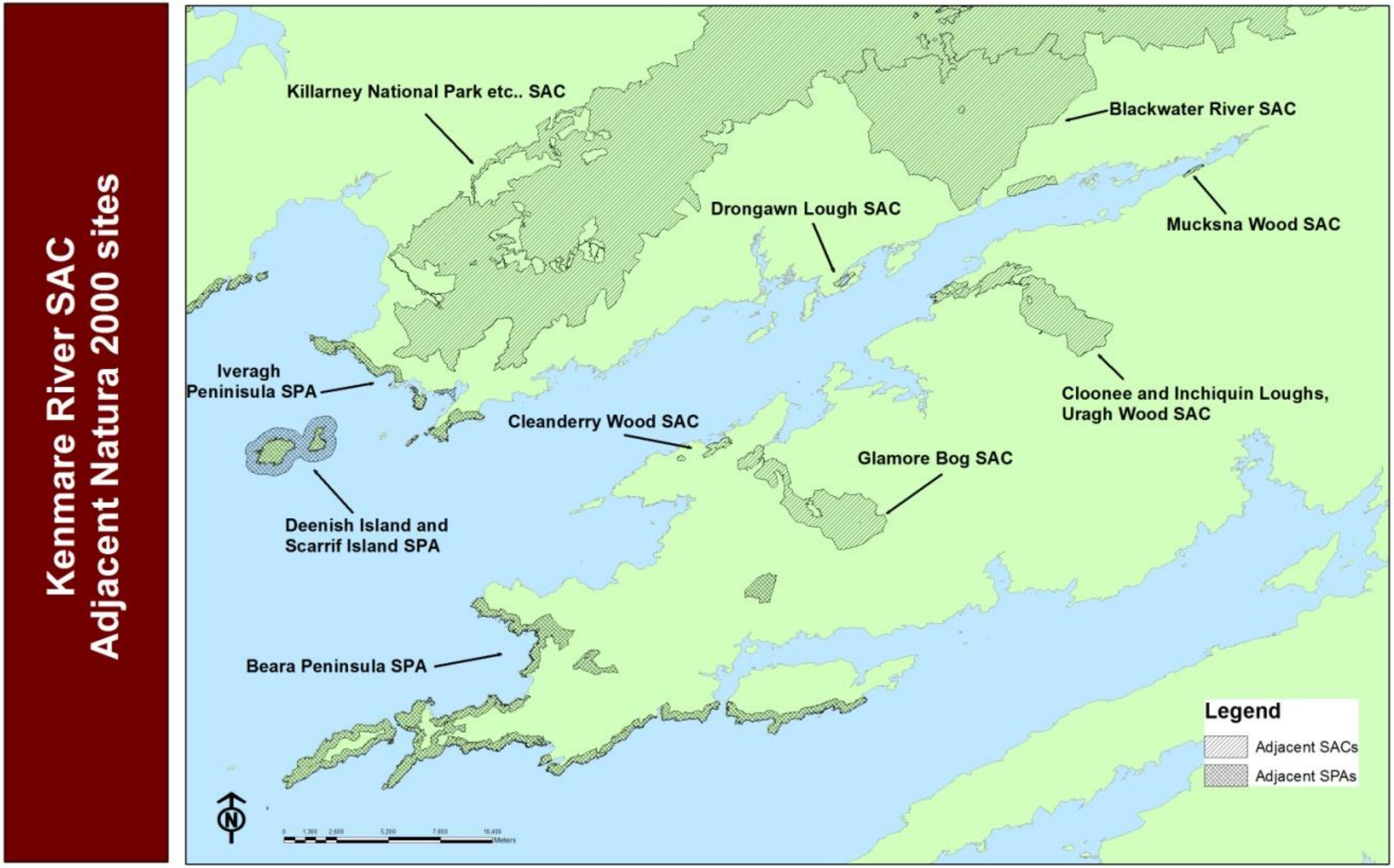

Figure 4. **Natura 2000 sites adjacent to the Kenmare River SAC.**

Table 1: Conservation objectives and targets for marine habitats and species in Kenmare River SAC (Site Code 002158) (NPWS 2013a, 2013b). Annex I and II features listed in bold.

Feature (Community Type)	Objective	Target(s)
Large shallow inlets and bays	Maintain favourable conservation condition	39,322ha;Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
(Intertidal mobile sand community complex)	Maintain favourable conservation condition	63.07ha; Maintained in a natural condition
(*Zostera* dominated communities)	Maintain favourable conservation condition	20.04ha; Maintain natural extent and high quality of *Zostera* dominated communities
(Maërl-dominated community)	Maintain favourable conservation condition	46.82ha; Maintain natural extent and high quality of Maërl dominated communities
(*Pachycerianthus multiplicatus* community)	Maintain favourable conservation condition	6.23ha; Maintain natural extent and high quality of *Pachycerianthus multiplicatus* community
(Muddy fine sands dominated by polychaetes and *Amphiura filiformis* community complex)	Maintain favourable conservation condition	20,141.20ha; Maintained in a natural condition
(Fine to medium sand with crustaceans and polychaetes community complex)	Maintain favourable conservation condition	1987.75ha; Maintained in a natural condition
(Coarse sediment dominated by polychaetes community complex)	Maintain favourable conservation condition	8,309.80ha; Maintained in a natural condition
(Shingle)	Maintain favourable conservation condition	1.42ha; Maintained in a natural condition
(Intertidal reef community complex)	Maintain favourable conservation condition	525.46ha; Maintained in a natural condition
(*Laminaria*-dominated community complex)	Maintain favourable conservation condition	3,356.63ha; Maintained in a natural condition
(Subtidal reef with echinoderms and faunal turf community complex)	Maintain favourable conservation condition	4805.86ha; Maintained in a natural condition
Reefs	Maintain favourable conservation condition	9,196ha; The distribution and permanent area is stable or increasing, subject to natural processes.
(Intertidal reef community complex)	Maintain favourable conservation condition	680.26ha; Maintained in a natural condition
(Subtidal reef with echinoderms and faunal turf community complex)	Maintain favourable conservation condition	4,835.43ha; Maintained in a natural condition
(*Laminaria*-dominated community complex)	Maintain favourable conservation condition	3,676.57ha; Maintained in a natural condition
Perennial vegetation of stony banks	Maintain favourable conservation condition	Area unknown; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.

Feature (Community Type)	Objective	Target(s)
Vegetated sea cliffs of the Atlantic and Baltic coasts	Maintain favourable conservation condition	>72.2ha; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Maintain favourable conservation condition	2.65ha; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
Mediterranean salt meadows (*Juncetalia maritimi*)	Maintain favourable conservation condition	17.90ha;Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species
Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes")	Maintain favourable conservation condition	1.67ha;Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species
Fixed coastal dunes with herbaceous vegetation (grey dunes)	Maintain favourable conservation condition	20.41ha; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species
European dry heaths	Maintain favourable conservation condition	>300ha; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species and disturbance
Calaminarian grasslands of the *Vioetalia claminariae*	Maintain favourable conservation condition	3.1ha: Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species and disturbance (soil toxicity).
Submerged or partially submerged sea caves	Maintain favourable conservation condition	Area unknown; Targets relate to maintaining distribution and managing human activities.
Marsh Snail *Vertigo angustior*	Maintain favourable conservation condition	A single site is identified for this species and targets relate to maintaining adult and sub-adult densities and overall habitat quality.
Otter *Lutra lutra*	Restore favourable conservation conditions	Maintain distribution - 88% positive survey sites.

Feature (Community Type)	Objective	Target(s)
		2748ha; No significant decline in extent of marine habitat; Couching sites and holts - no significant decline and minimise disturbance: Fish biomass - No significant decline in marine fish species in otter diet. Barriers to connectivity - No significant increase.
Harbour Seal *Phoca vitulina*	Maintain favourable conservation condition	The range of use within the site should not be restricted by artificial barriers; all sites should be maintained in natural condition; human activities should occur at levels that do not adversely affect harbour seal population at the site.
Lesser Horseshoe Bat (*Rhinolophus hipposideros*)	Maintain favourable conservation condition	The range of use within the site should not be restricted by artificial barriers; all sites should be maintained in natural condition; human activities should occur at levels that do not adversely affect the Lesser Horsehoe Bay population at the site.

4.4 Screening of Adjacent SACs or for *ex-situ* effects

In addition to the Kenmare River SAC there are a number of other Natura 2000 sites proximate to the proposed activities (Figure 4). The characteristic features of these sites are identified in Table 2 where a preliminary screening is carried out on the likely interaction with aquaculture activities based primarily upon the likelihood of spatial overlap. As it was deemed that there are no *ex situ* effects and no effects on features in adjacent SACs all qualifying features of adjacent Natura 2000 sites were screened out.

Table 2 Natura Sites adjacent to Kenmare River SAC and qualifying features with initial screening assessment on likely interactions with aquaculture activities.

NATURA SITE	QUALIFYING FEATURES [HABITAT CODE]	AQUACULTURE INITIAL SCREENING
Old Domestic Building , Dromore Wood SAC (000353)	Lesser Horseshoe Bat (*Rhinolophus hipposideros*) [1303]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Cleanderry Wood SAC (001043)	Killarney Fern *Trichomanes speciosum* [1421]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Old sessile oak woods with Ilex and Blechnum in the British Isles [91A0]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Cloonee and Inchiquin Loughs, Uragh Wood SAC (001342)	Kerry slug *Geomalacus maculosus* [1024]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Lesser horseshoe bat *Rhinolophus hipposideros* [1303]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Killarney fern *Trichomanes speciosum* [1421]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Slender naiad *Najas flexilis* [1833]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*) [3110]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis

Natura site	**Qualifying features [Habitat code]**	**Aquaculture Initial Screening**
	Old sessile oak woods with Ilex and Blechnum in British Isles [91A0]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Mucksna Wood SAC (001371)	Old sessile oak woods with Ilex and Blechnum in British Isles [91A0]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Glanmore Bog SAC (001879)	Freshwater pearl mussel (*Margaritifera margaritifera*) [1029]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Killarney fern (*Trichomanes speciosum*) [1421]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*) [3110]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Northern Atlantic wet heaths with *Erica tetralix* [4010]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Blanket bog (*active only) [7130]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Drongawn Lough SAC (002187)	Coastal lagoons [1150]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis

NATURA SITE	QUALIFYING FEATURES [HABITAT CODE]	AQUACULTURE INITIAL SCREENING
Blackwater River (Kerry) SAC (002173)	Kerry slug (*Geomalacus maculosus*) [1024]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Freshwater pearl mussel (*Margaritifera margaritifera*) [1029]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Salmon (*Salmo salar*) [1106]	Migrating salmon passing through Kenmare River SAC and could interact with activities covered in this assessment- **carry forward to Section 8.**
	Lesser horseshoe bat (*Rhinolophus hipposideros*) [1303]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Otter (*Lutra lutra*) [1355]	Otter may migrate into Kenmare River SAC and could interact with aquaculture and fisheries activities **– carry forward to Section 8.**
	European dry heaths [4030]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Iveragh Peninsula SPA (004154)	Fulmar (*Fulmarus glacialis*) [A009]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis [4]
	Peregrine (*Falco peregrinus*) [A103]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis

[4] http://www.npws.ie/media/npwsie/content/images/protectedsites/sitesynopsis/SY004154.pdf

NATURA SITE	QUALIFYING FEATURES [HABITAT CODE]	AQUACULTURE INITIAL SCREENING
	Kittiwake (*Rissa tridactyla*) [A188]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
	Guillemot (*Uria aalge*) [A199]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
	Chough (*Pyrrhocorax pyrrhocorax*) [A346]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
Beara Peninsula SPA (004155)	Fulmar (*Fulmarus glacialis*) [A009]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis [5]
	Chough (*Pyrrhocorax pyrrhocorax*) [A346]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
Deenish Island and Scariff Island SPA (004175)	Fulmar (*Fulmarus glacialis*) [A009]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis [6]
	Manx Shearwater (*Puffinus puffinus*) [A013]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis

[5] http://www.npws.ie/media/npwsie/content/images/protectedsites/sitesynopsis/SY004155.pdf
[6] http://www.npws.ie/media/npwsie/content/images/protectedsites/sitesynopsis/SY004175.pdf

Natura site	**Qualifying features [Habitat code]**	**Aquaculture Initial Screening**
	Storm Petrel (*Hydrobates pelagicus*) [A014]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
	Lesser Black-backed Gull (*Larus fuscus*) [A183]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
	Arctic Tern (*Sterna paradisaea*) [A194]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis

5. Details of the proposed plans and projects

5.1 Aquaculture

Aquaculture in the Kenmare River SAC focuses on shellfish species (mussels, oysters scallops and clams) and finfish (Salmon) (Figures 5 and 6). Mussels are the predominant shellfish species cultured within the SAC. Small quantities of oysters are produced; while Scallops and Clams, although licensed, are not currently produced in the area. There are also six locations dedicated to the culture of Atlantic Salmon. Descriptions of spatial extents of existing and proposed activities within the qualifying interests of the Kenmare River SAC were calculated using coordinates of activity areas in a GIS. The spatial extent of the various aquaculture activities (current and proposed) overlapping the habitat features is presented in Table 3 (data provided by DAFM).

5.1.1 Oyster Culture

Oyster farming within Kenmare River is a form of intensive culture which has been taking place since the early 1990s. A single species forms the basis of oyster aquaculture operation in the Kenmare River SAC, i.e. the Pacific oyster, *Crassostrea gigas.* The seed is cultivated using the bag and trestle method, either to half-grown or fully-grown size. The bag and trestle method uses steel table-like structures which rise from the shore to just above knee height on the middle to lower intertidal zone, arrayed in double rows with wide gaps between the paired rows to allow for access. The trestles hold HDPE bags approximately 1m by 0.5m by 10cm, using rubber and wire clips to close the bags and to fasten them to the trestles. When first put to sea, there may be up to 2000 oysters in a single bag, but as they grow and are graded this number is gradually reduced. Over the course of the two or three years that it takes an oyster to reach saleable size, the density is reduced until market ready oysters, of approximately 100g each (when grown to full size) are being grown in bags of approximately 100 oysters per bag. The bags need to be shaken, turned and re-secured occasionally to prevent build-up of fouling and to ensure the growing oysters maintains a good marketable shape. This usually takes place once on each tidal cycle, when maximum exposure of the shore allows safe access to all trestles. It is most important during the summer months when plankton, the oysters' food, is abundant and oyster growth rates are at their optimum. Oysters are grown on in these bags to half-grown or full grown size for up to three years, and will be graded two or three times over the course of each summer.

There are four sites in operation, three in Templenoe and one in Coongar Harbour. These operations are relatively small, currently producing less than 30 tonnes annually, they are classified as free from the herpes virus and at the moment the operators are buying in seed from Seasalter, both diploid and triploid, depending on availability. This availability means that there is currently no generalised production cycle. Sites are accessed at low tide using a tractor and trailer, by a public road near Templenoe and by boat in Coongar Harbour.

There are a number of applications for new licences for bag and trestle oyster culture, in Killmakilloge and Ardgroom Harbour, which would be accessed by boat from the local piers and one on the south shore of Kenmare River, near Killaha East which would be accessed by shore from the applicants own property. Some of these are for multi species licences, to include native oysters, mussels, but still using the bag and trestle method of cultivation.

5.1.2 Rope Mussels

There are a number of very productive locations for suspended long-line mussel farming in Kenmare River, namely Killmakilloge Harbour (600 – 1000 tonnes), Ardgroom Harbour, including Coosmore and Cleanderry Harbour (700 – 1100 tonnes) and Coongar Harbour, including Sneem Harbour (150 – 200 tonnes). All of the farms are locally owned, providing quite large scale local employment. The main piers in use are located close to these growing areas.

The culture method involves placing, an often re-usable, settlement media (rope, strap, mesh) in the water column, known as a ‘dropper’ on which natural juvenile mussels settle, depending on a number of seasonal and local factors this takes place in April, May or June, the naturally collected mussel seed is then on-grown for typically 18-24 months before being harvested as per market requirements and in line with shellfish and water quality parameters. Some of the larger farmers operate as contract service providers, carrying out the harvesting for the smaller farmers, using their purpose built work barges, although for the most part the farmers work their own farms using smaller converted fishing vessels. As these mussels grow the ‘droppers’ are often moved to grow-out areas, or remain in situ. Some farms grade the mussels during the 18-24 months, using the “New Zealand” continuous rope system, whereby the mussels are re-packed at a specific density using bio-degradable cotton mesh around the rope, the mesh rots away after the mussels have re-attached using their byssal threads. All of the long-lines in use are double head rope longlines, constructed from polypropylene mostly of 110m in length, with typically 30 x 210-250l floatation units (mostly grey in colour) and anchored at each end with 2.5 tonne concrete weights. In general the long-line density is no greater than 3 lines per hectare. In Ardgroom Harbour the mussel farmers, through the CLAMS process set a self-imposed stocking density of 2 longlines per hectare and a dropper limit of 406 per line.

There are a number of long-line licence applications in the traditional areas of Ardgroom, Killmakilloge and Coongar Harbours as well as an expansion into deeper, more exposed waters of Kenmare River and in Coulagh Bay. A number of these newer long-line licence applications are for multi-species licences, to include mussels, oysters and native seaweeds.

A single trial application has been submitted for a mussel longline system in the main body of Kenmare River (Figure 7).. The purpose of the trial is to establish the technical feasibility of a novel rope cultivation system.

The experimental deployment will include 3 mussel lines of 40m (at surface) 180m (total length including full length of moorings) in the proposed site for a period of 18 months. Drop lines (per surface line) will be seeded with mussels (7-10mm locally sourced) and suspended at a range of depths between 5m and 35m. Monthly measurements of growth will be taken. Environmental monitoring will include high frequency data on wave height, current speed and direction, temperature and salinity, and periodic manual observations will also be conducted (e.g. plankton tows, water samples for chlorophyll measurements). Following the trial period of 18 months all field trial equipment will be removed from the area.

5.1.3 Salmon Culture

Salmon (*Salmo salar*) is currently produced at 4 sites within the Kenmare River SAC. Five sites are licensed to produce salmon, one of which is also licensed to produce Rainbow trout (*Oncorhynchus mykiss*). There is also one licence application for salmon production.

Marine Harvest Ireland (MHI) operates two sites, Inisfarnard and Deenish. At both sites there is space for fourteen 128m circumference net pens, with 15m sides. The cubic capacity of each net pen is 19,600m^3, leading to an overall volume of 274,400m^3 and at maximum allowable stocking density, a potential standing stock of 2,744 tonnes. Each site also has a feed barge, moored on site, which can hold a maximum of 200 tonnes of feed. The feed barge can feed the stock automatically throughout the day, each net pen has cameras installed to monitor the fish, optimising feed conversion rate and minimising waste. The sites operate on a two year annual alternate site stocking cycle, inputting 800,000 smolts, to each site alternately and harvesting them in year two from months 16 to 22. The site is then left fallow for two months before next smolt input. These sites are accessed from piers in Castletownbere, Travarra and Ballycrovane.

Murphy's Irish Seafood Ltd operates the other two sites, St. Killians and Doon Point. St Killians, in Killmakilloge Harbour, a 160 tonne licenced site (leased from St. Killian's Salmon Ltd), has three 70m net pens and is currently operating as a smolt site holding the fish for one year before being transferred to a main grower site. The Doon Point site is currently fallow, but has a licenced capacity of similar to the MHI sites above. These sites are accessed from Cleandra and Killmakilloge in Kenmare River and Gearhies in Bantry Bay.

The smolts for these sites come from a number of sources. Smolt is the name given to juvenile salmon, when they would naturally travel from fresh water, where they are hatched and develop, approximately for one year, to salt water for feeding and further growth before returning to the same fresh water to breed. The smolts for the MHI operation are currently produced in the MHI freshwater facilities in Donegal, namely Altan and Pettigoe. Murphy's Irish Seafood Ltd, whilst producing most of their smolt requirements from their Borlin hatchery also buy in smolt from Derrylea Holdings Ltd. All of these smolts are trucked from the freshwater facilities to a well boat for delivery to the sea sites. Once at sea the smolts are reared in nets suspended from circular floating structures known as pens. These are moored in groups, in locations where there are strong water flows in order to provide the stock with optimum environmental conditions, as salmon are extremely sensitive to pollution and only grow if the waters in which they live are clean and well oxygenated. The smolts are initially fed by hand but as they grow, mechanical feed systems are used.

All sites are operating according to EU Organic Aquaculture standards[7], which include low stocking densities and the use of organically certified food. The nets are made of knotless netting and no anti-fouling treatment is allowed, nets are either cleaned *in-situ* using pressurised water systems or alternatively when the need arises the nets are changed. Regular dive inspections are carried out on the nets and moorings.

5.1.4 Scallops

Within the Kenmare River SAC, there are eleven sites licensed for the production of scallops and also two applications (Ballycrovane and Killmakilloge Harbours). None of the licensed scallop sites are currently active. Scallops are dredged from the seafloor within these licensed areas. There is little or no intervention to improve stocks. The activities effectively equate to a wild fishery.

At the two application sites (Killmakillogue and Ballycrovane Harbours), juvenile scallops would be purchased either from a hatchery or from wild collection and broadcast on the sea bed; these would then be left to grow, to be harvested by divers.

5.1.5 Clams

There is a single licence for clam cultivation in conjunction with oysters. Clams have never been farmed on site and currently the site is being used to farm oysters on bag and trestle. If clams were to be farmed, they would be seeded in the ground, under nets, the clams would then be raked by hand for grading and harvesting.

5.2 Description of Fishing Activities

5.2.1. Pot fisheries

Six vessels less than 8m in length fish for lobster and crab along the coast from Ballinskelligs into Kenmare River using 1500 pots and a further 8 vessels under 10m in length fish 2500 pots in inner Kenmare. A further 19 vessels fishing 9500 pots fish for shrimp (*Palaemon serratus*) in inner Kenmare. Potting for prawns (Nephrops) occurs at the edge of trawling ground in outer and mid Kenmare (Fig. 7).

5.2.2. Dredge fisheries

Scallops are fished with dredges on the south shore of inner Kenmare.

5.2.3. Set net fisheries

Tangle netting for crayfish occurs at the outer edges of the SAC and in coastal waters to the north and south of the site (Fig. 8).

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[7] http://www.bim.ie/our-services/grow-your-business/farmedfishqualitylabelling/organicassurancelabellingschemes/

5.2.4. Bottom trawl fisheries

Bottom trawl fisheries, targeting *Nephrops* and mixed demersal fish, occurs on fine sedimentary habitats in outer Kenmare River.

5.2.5. Pelagic fisheries

Pelagic trawling for sprat occurs in winter in inner Kenmare River (Fig. 9).

5.2.6. Hook and line fisheries

Inshore fishing vessels fish for Mackerel and Pollack in outer Kenmare River SAC in summer and autumn (Fig. 10)

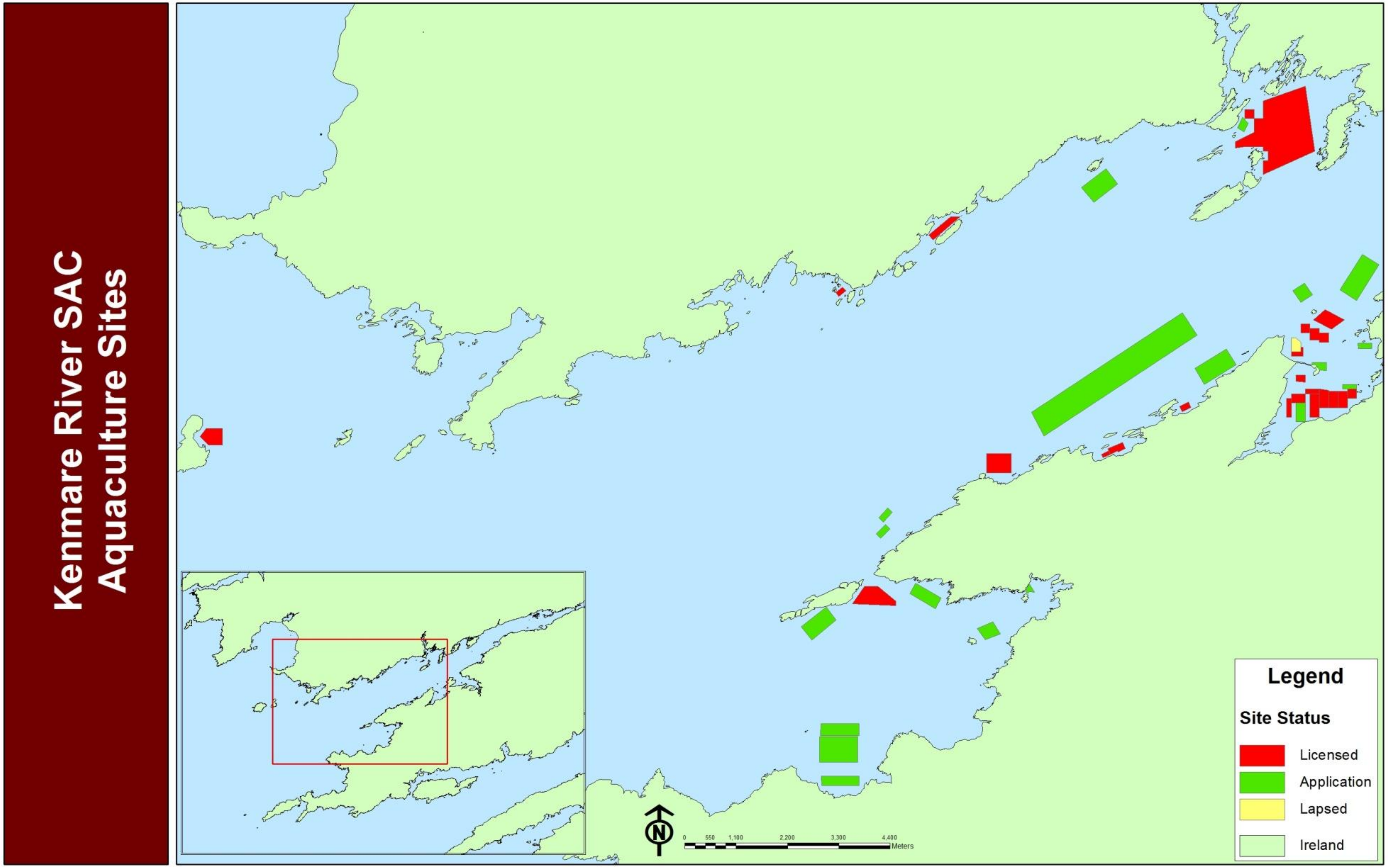

Figure 5 Aquaculture sites (Licenced and Applications) in western portion of Kenmare River SAC (Site Code 002158).

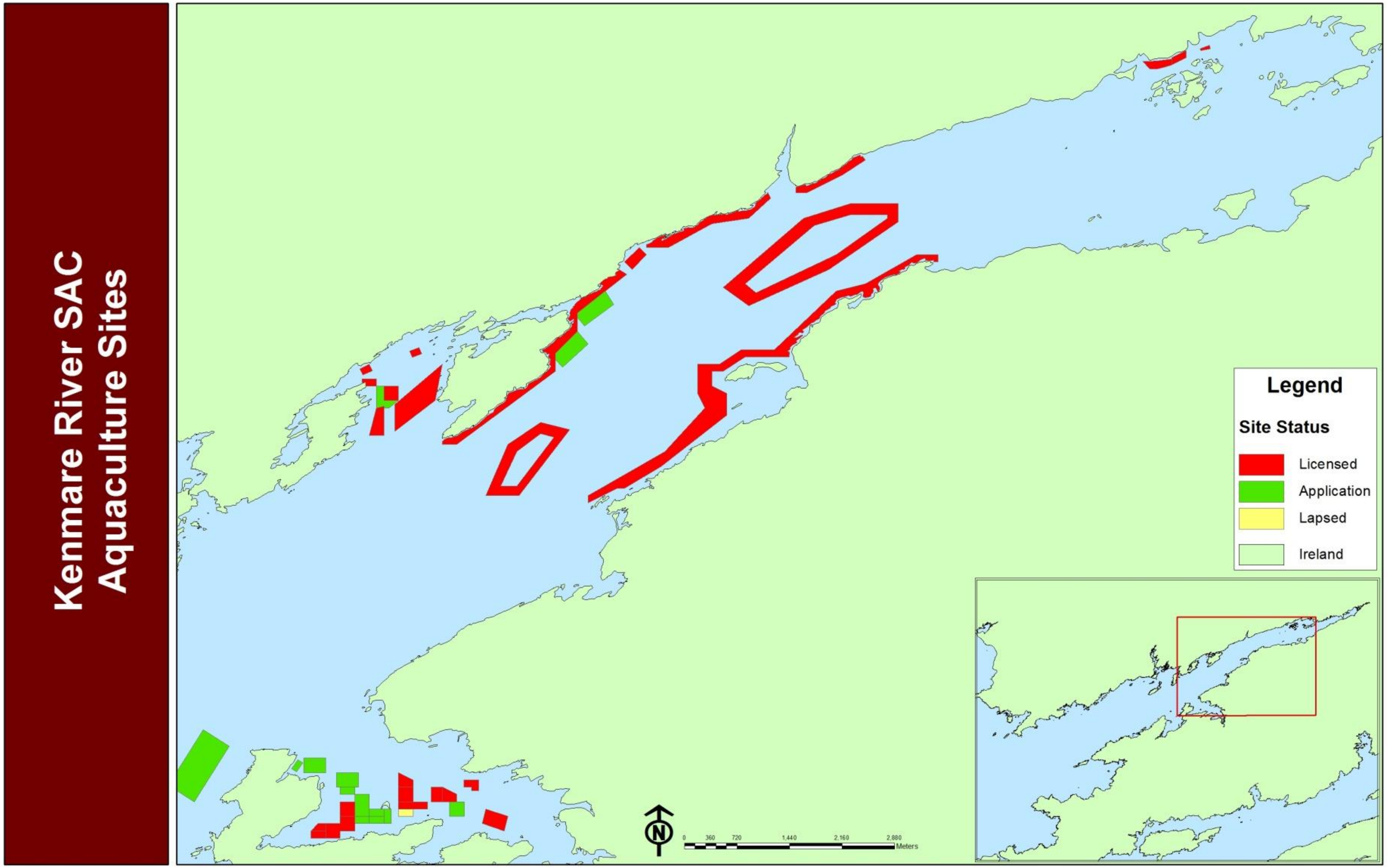

Figure 6 Aquaculture sites (Licenced and Applications) in eastern portion of Kenmare River SAC (Site Code 002158).

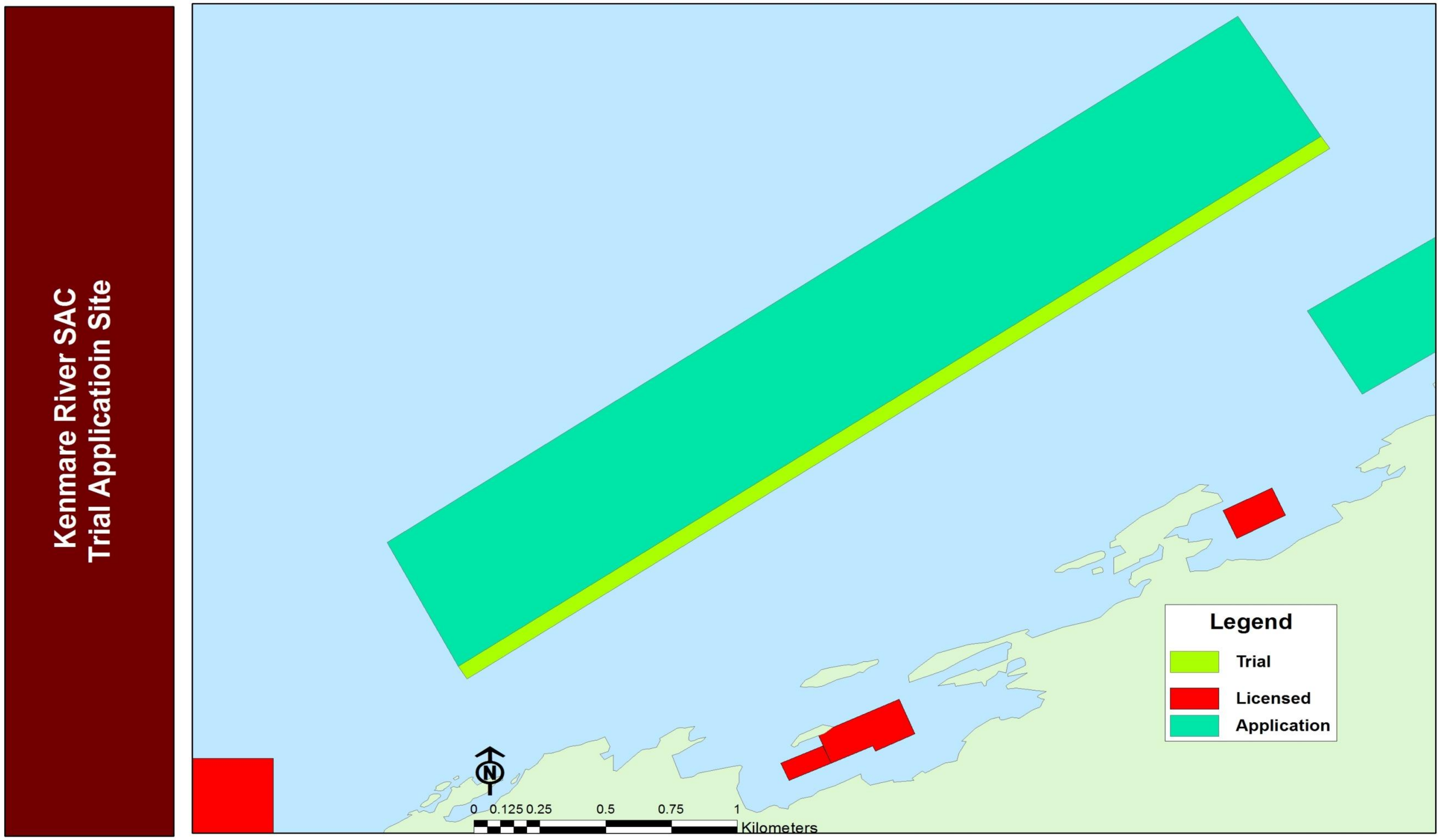

Figure 7 Trial aquaculture site for rope mussel culture system in central portion of Kenmare River SAC (Site Code 002158).

Table 3: Spatial extent (ha) of aquaculture activities overlapping with the qualifying interest (1160 Large shallow inlets and bays and 1170 Reefs) in Kenmare River SAC (Site Code 002158), presented according to culture species, method of cultivation and license status.

Species	Status	Location	1160 - Large shallow inlets and Bays		1170 - Reefs	
			Area (ha)	**% Feature**	**Area (ha)**	**% Feature**
Oysters	Licensed	Intertidal	7.53	0.02	1.54	0.02
Oysters	Application	Intertidal	16.03	0.04	15.23	0.17
Mussels	Licensed	Subtidal	23.46	0.06	37.65	0.41
Mussels	Application	Subtidal	469.29	1.19	136.44	1.48
Finfish	Licensed	Subtidal	62.67	0.16	12.13	0.13
Finfish	Application	Subtidal	31.89	0.08	14.51	2.232E-07
Scallops	Licensed	Subtidal	473.10	1.20	209.11	2.27
Scallops	Application	Subtidal	1.87	4.76E-03	1.86	0.02
Totals			**1062.3 ha**	**2.69%**	**426.34 ha**	**4.48%**

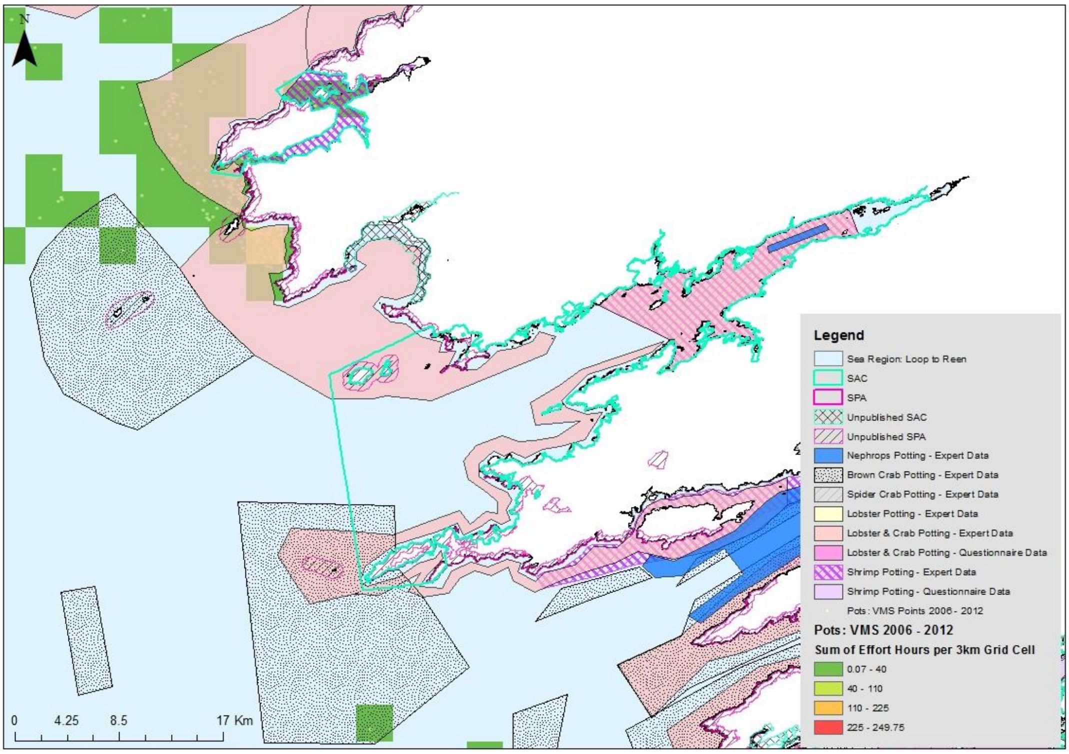

Figure 8. Pot fishing activity in the region of Kenmare River SAC

Figure 9. Set net fishing activity in the region of Kenmare River SAC

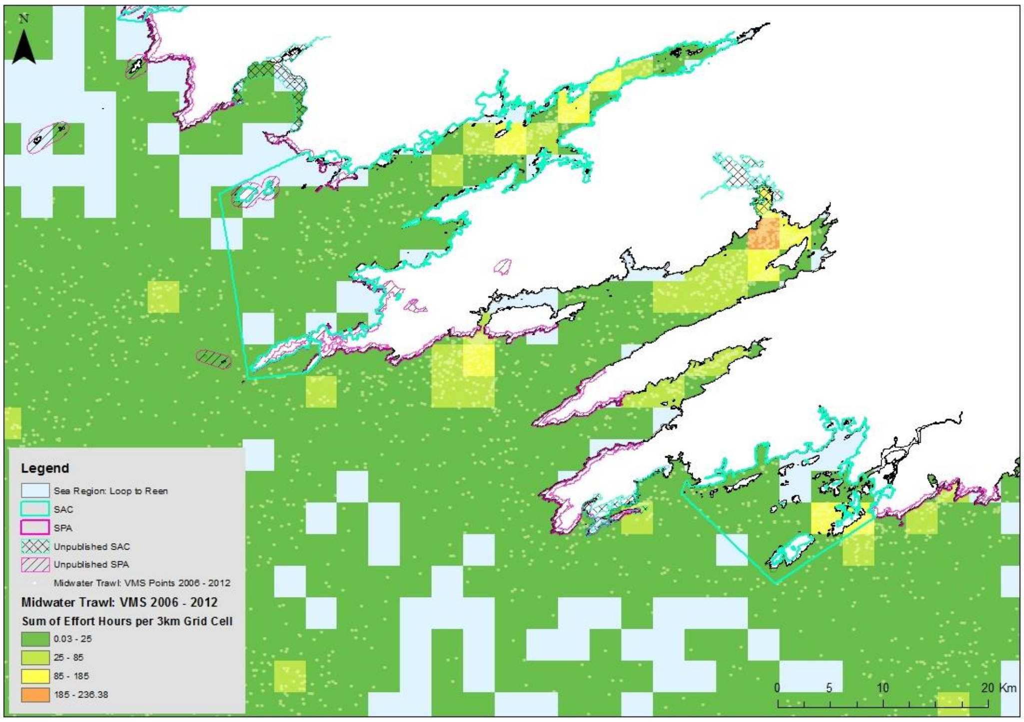

Figure 10. Pelagic fishing activity in the region of Kenmare River SAC

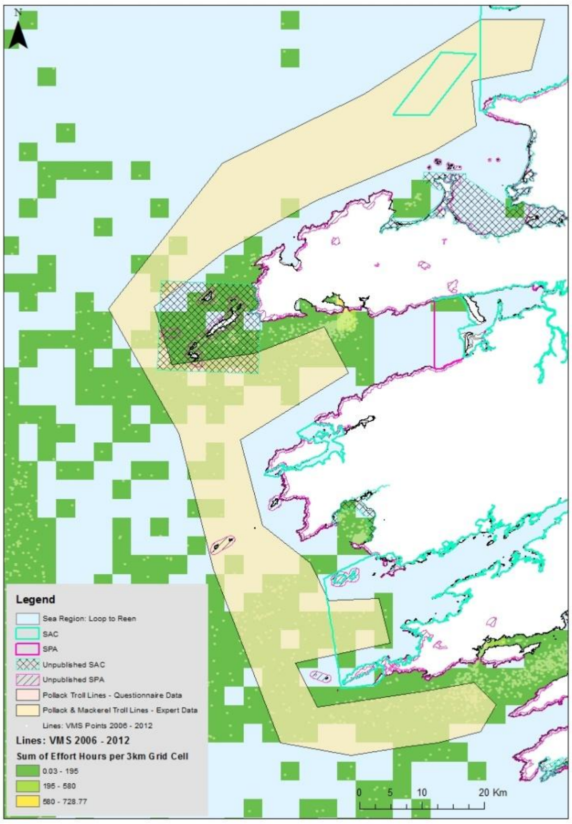

Figure 11. Hook and line fishing activity in the region of Kenmare River SAC

6. Natura Impact Statement for the Activities

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

6.1 Aquaculture

Within the qualifying interest of the Kenmare River SAC, the species cultured are:

- Mussels (*Mytilus edulis*) in suspended culture (Rope culture) in subtidal areas.
- Oysters (*Crassostrea gigas*), in suspended culture (bags & trestles) confined to intertidal areas.
- Scallops (*Pecten maxius*) subtidally on the seafloor.
- Clams (*Ruditapes philippinarum*) on the seafloor intertidally.
- Atlantic salmon (*Salmo salar*) in net pens.

Details of the potential biological and physical effects of these aquaculture activities on the habitat features, their sources and the mechanism by which the impact may occur are summarised in Table 4, below**.** The impact summaries identified in the table are derived from published primary literature and review documents that have specifically focused upon the environmental interactions of mariculture (e.g. Black 2001; McKindsey *et al*. 2007; NRC 2010; O'Beirn *et al* 2012; Cranford *et al* 2012; ABPMer 2013a-h).

Filter feeding organisms, for the most part, feed at the lowest trophic level, usually relying primarily on ingestion of phytoplankton. The process is extractive in that it does not rely on the input of feedstuffs in order to produce growth. Suspension feeding bivalves such as oysters and mussels can modify their filtration to account for increasing loads of suspended matter in the water and can increase the production of faeces and pseudofaeces (non-ingested material) which result in the transfer of both organic and inorganic particles to the seafloor. This process is a component of benthic-pelagic coupling (Table 3). The degree of deposition and accumulation of biologically derived material on the seafloor is a function of a number of factors discussed below.

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

Suspended Shellfish Culture: Suspended culture, may result in faecal and pseudo-faecal material falling to the seabed. In addition, the loss of culture species to the seabed is also a possibility. The degree to which the material disperses away from the location of the culture system (longlines or trestles) depends on the density of mussels on the line, the depth of water and the current regime in the vicinity. Cumulative impacts on seabed, especially in areas where assimilation or dispersion of pseudofaeces is low, may occur over time. A number of features of the site and culture practices will govern the speed at which pseudofaeces are assimilated or dispersed by the site. These relate to:

- Hydrography – will govern how quickly the wastes disperse from the culture location and the density at which they will accumulate on the seafloor.
- Turbidity in the water - the higher the turbidity the greater the production of pseudo-faeces and faeces by the filter feeding animal and the greater the risk of accumulation on the seafloor.
- Density of culture – suspended mussel culture is considered a dense culture method with high densities of culture organisms over a small area. The greater the density of organisms the greater the risk of accumulations of material. The density of culture organisms is a function of:
    - depth of the site (shallow sites have shorter droppers and hence fewer culture organisms),
    - the husbandry practices proper maintenance will result in optimum densities on the lines in order to give high growth rates as well as reducing the risk of drop-off of culture animals to the seafloor and sufficient distance among the longlines to reduce the risk of cumulative impacts in depositional areas.

In addition placement of structures associated with mussel culture can influence the degree of light penetration to the seabed. This is likely important for organisms and habitats e.g. Maërl and seagrasses which need sun light for production. Rafts or lines will to a degree limit light penetration to the sea bed and may therefore reduce production of photosynthesising species. However, such effects have not been demonstrated for seagrass.

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

- Hydrography – low current speeds (or small tidal range) may result in material being deposited directly beneath the trestles. If tidal height is high and large volumes of water moved through the culture area an acceleration of water flow can occur beneath the trestles and bags, resulting in a scouring effect or erosion and no accumulation of material.
- Turbidity of water – as with suspended mussel culture, oysters have very plastic response to increasing suspended matter in the water column with a consequent increase in faecal or pseudo-faecal production. Oysters can be cultured in estuarine areas (given their polyhaline tolerance) and as a consequence can be exposed to elevated levels of suspended matter. If currents in the vicinity are generally low, elevated suspended matter can result in increase build-up of material beneath culture structures.
- Density of culture – the density of oysters in a bag and consequently the density of bags on a trestle will increase the likelihood of accumulation on the seafloor. In addition, if the trestles are located in close proximity a greater dampening effect can be realised with resultant accumulations. Close proximity may also result in impact on shellfish performance due to competitive interactions for food.
- Exposure of sites - the degree to which the aquaculture sites are exposed to prevailing weather conditions will also dictate the level of accumulated organic material in the area. As fronts move through culture areas increased wave action will resuspend and disperse material away from the trestles.

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

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

Intertidal culture of clam species is typically carried out in the sediment covered with netting to protect the stock from predators. The high density of the culture organisms can lead to exclusion of native biota and the ground preparation and harvest methods (by mechanical means or by hand) can lead to considerable disturbance of biota characterising the habitat.

Sub-tidal shellfish culture i.e. Scallops: This activity involves relaying shellfish on the seabed. There may be increased enrichment due to production of faeces and pseudofaeces in high density cultures. The existing in-faunal community may be changed as a result. Seabed habitat change may also result as a result of dredging during maintenance and harvesting. Uncontained sub-tidal shellfish culture will lead to change in community structure and function through the addition, at high % cover, of an epi-benthic species (living on the seabed) to an infaunal sedimentary community.

The activities associated with this culture practice (dredging of the seabed) are considered disturbing which can lead to removal and/or destruction of infaunal species and changes to sediment composition.

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

Oyster culture poses a risk in terms of the introduction of non-native species as the Pacific oyster (*Crassostrea gigas*) is a non-native species. Recruitment of *C. gigas* has been documented in a number of Bays in Ireland and appears to have become naturalised (i.e. establishment of a breeding population) in two locations (Kochmann et al 2012; 2013) and may compete with the native species for space and food. The culture of large volumes of Pacific oysters may increase the risk of successful reproduction in Kenmare River SAC. The use of triploid (non-reproducing) stock is the main method employed to mange this risk. Furthermore, the introduction of non-native species as 'hitchhikers' on and among culture stock is also considered a risk, the extent of which is dependent upon the duration the stock has spent 'in the wild' outside of Kenmare River. 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 Kenmare Bay, 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/). The manila clam, *Ruditapes philippinarum*, has not been cultured in the bay as yet. No record of this species has been recorded in the wild in Ireland since its introduction in 1984.

Finfish Culture: Within the Kenmare River SAC there are six (5 licensed, 1 application) marine sites assigned for the culture of salmon (and other finfish). Four of these sites are currently active in the production of salmon (*Salmo salar*).

Finfish culture differs from shellfish culture in that there is an input of feed into the system and as a consequence a net input of organic matter to the system. This material will be found in the system in the form of waste feed (on the seafloor), solid waste (faeces), waste as a consequence of net-cleaning all of which usually accumulates on the seafloor and dissolved material (predominantly fractions rich in nitrogen). For the most part, the majority of organic material builds up on the seabed generally in and around the footprint of the salmon cages with a 'halo' effect evident in areas where dispersion occurs driven by local hydrographic conditions. This is typically referred to a *near-field* effects. Similar to shellfish, the quantity of material that might accumulate on the seabed will be a function of the quantity of fish held in cages, the stage of culture, the health of the fish (unhealthy fish will generally eat less), husbandry practices (are the fish fed too much too quickly?), the physical characteristic of the solid particles and, as mentioned above, hydrographic conditions.

Wildish et al. (2004) and Silvert and Cromey (2001) both summarize the factors (listed above) that govern the level of dispersion of material from the cages to the seafloor. Many of the factors are subsequently incorporated into modelling efforts which are used to predict likely levels of impact. The impact of organic matter on sedimentary seafloor habitat typically evolves after the gradient defined by Pearson-Rosenberg (1978), whereby as the level of organic enrichment increases the communities (macrofaunal species number and abundance) found within the sedimentary habitats will also change. Typically, low levels of enrichment facilitates an increase in species abundance and biomass followed by a decrease in all biological metrics as enrichment increases to a point where azoic conditions prevail and no biota are found. The impact on biota is a consequence of the decrease in oxygen and a build-up of by-products such as ammonia and sulphides brought about by the breakdown of the organic particles which are considered toxic to marine biota. The shift from an oxygenating to reducing environment in the sediment could be such that the effect is mirrored in the water column as well (i.e. reduction in oxygen levels). The output of dissolved material resulting from finfish cages is typically in the form of ammonia, phosphorous and dissolved organic carbon (DOC) originating directly from the culture organisms, or from the feed and/or faecal pellets. Similar to particulate waste, the impact of dissolved material is a function of the extent (intensity) of the activity and properties of the receiving environment (e.g., temperature, flushing time). While elevated levels of nutrient have been reported near fish farms, no significant effect on chlorophyll has been demonstrated (Pearson and Black, 2001).

Diseases: It is likely that the first outbreaks of infectious diseases in marine aquaculture operations were caused by pathogens originating in wild hosts and as culture extent and intensity increases the transmission of pathogens (back) to the wild fish stocks is a likely consequence. The result of such pathogen transmission back to wild fish is however unknown, as reports of clinical effects or significant mortality in wild fish populations are largely unavailable. Numerous reviews, models, risk assessments and risk analysis have been carried out or developed in order to determine the potential for disease interaction and pathogen exchange between farmed and wild finfish (OIE 2004, Bricknell *et al*. 2006, DIPNET 2006, Peeler *et al*. 2007). On foot of these outputs there is general acceptance among scientists and managers that pathogens can be transmitted between organisms used in mariculture and those found in the wild and vice-versa (ICES 2013).

The risk of infection in marine organisms, are influenced by a number of environmental factors including temperature, salinity and dissolved oxygen (Grant and Jones 2011), as well as factors particular to the biology of pathogen, e.g., replication rates, virulence. Transmission of pathogens is facilitated by one or a combination of three mechanisms, i.e., horizontal, vertical and vector-borne. Horizontal transmission refers to the direct movement through the water column of a pathogen between susceptible individuals and the open design of most mariculture cages allows the potential for bidirectional transmission of pathogens between wild and captive fish (Johansen *et al.* 2011). Vertical transmission involves the passing of a pathogen with milt or eggs, resulting in infection among offspring. Pathogens can also be spread by a third host or vector. Vectors can include other parasites, fish, piscivorous animals or inanimate objects such as clothing, vessels or equipment.

Disease transmission within culture systems is a primary concern of operators and as a consequence of monitoring and screening, a far greater knowledge base relating to disease causing organisms and their transmission is available relating to cultured stocks rather than wild stocks. As a result of the lack of empirical data relating to diseases specific to wild stocks, it has been difficult to partition population effects in wild-stocks caused by diseases from those caused by other processes (ICES 2010).

Ireland enjoys a high health status (Category 1) in relation to the fish/shellfish on farms, in rivers and lakes and remains free of many diseases that occur in other countries (www.fishhealth.ie). In Ireland, there are programmes in place that govern the movement of (fish and shellfish) stock for on-growing among sites. These movement controls are supported by a risk-based fish health surveillance programme which is operated on a nationwide basis by the Marine Institute, in co-operation with private veterinary practitioners. Ireland is currently free of the following salmonid diseases covered by (Council Directive 2006/88/EC):

- Infectious Salmon Anaemia (ISA)
- Viral Haemorrhagic Septicaemia (VHS)
- Infectious Haematopoetic Necrosis (IHN)
- Gyrodactylosis

Apart from the diseases listed under EU legislation, routine tests are carried out for other diseases found in marine salmonids in Ireland e.g. Pancreas Disease (PD), Infectious Pancreatic Necrosis (IPN), Furunculosis etc. Such diseases are present in Ireland and whilst their control is not covered by legislation, all finfish farmers in the country have agreed to comply with the parameters of a Code of Practice and Fish Health Handbook, jointly agreed between the Marine Institute and the Irish Farmers Association (IFA). These documents cover all aspects of disease prevention and control on Irish fish farms with the twin objectives of minimising disease outbreaks and of dealing with them in a timely and responsible fashion, should they arise. The net outcome should be a decrease in mortality rates on fish farms and a corresponding decrease in potential pathogen transfer to wild stocks. Ensuring the ongoing good health of farmed stocks and the regular monitoring of environmental conditions will also help to minimise the disease impacts which may be caused by infection from wild stocks in the vicinity of the cages.

Disease Management: Council Directive 2006/88/EC on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals form the legislative basis that governs the monitoring and management of disease outbreaks in mariculture operations in Ireland. For diseases not listed in this Directive, a Code of Practice and Fish Health Handbook has been developed jointly by the State and industry with the primary objectives of disease prevention and control.

The adoption of chemotherapeutants and some vaccination programmes have assisted in reducing the abundance and spread of many pathogens. In addition, the principles outlined in the Fish Health Handbook mentioned above such as improved biosecurity practices on farms, fallowing sites to break transmission cycles, disease testing of fish prior to transfer, single year class stocking, coordinating treatments and harvesting within embayments etc have mitigated the transmission of pathogenic organisms.

In summary, it is clear that a number of broad factors govern the transfer of diseases between susceptible organisms. While statistical correlations have been demonstrated in terms of abundance of cultured fish and disease occurrence in wild fishes, extreme caution must apply in terms of applying causality. It is important to note that the only way to determine the link between disease outbreaks in aquaculture installations and detection in wild fish is to empirically measure or observe pathogen transfer. Furthermore, when a risk presents, it not clear if the impact on the wild fish is expressed at the individual and/or population level. While certain effects have been demonstrated at the level of individuals, research has not yet clearly identified or quantified these links at the population level. Disease management programmes operated on a statutory basis by the State and on a voluntary basis by industry *via* Codes of Practice, assist in ensuring that pathogen transfer both to and from farmed fish is kept to a minimum.

Parasites: Sea lice are a group of parasitic copepods found on fish worldwide. There are two species of sea lice commonly found on cultured salmonids in marine conditions around the coast of Ireland, *Caligus elongatus* Nordmann, which infests over eighty different species of marine fish, and *Lepeophtheirus salmonis* Krøyer (the salmon louse), which infests only salmon, trout and closely related salmonid species. *L. salmonis*, the salmon louse, is the more serious parasite on salmon, both in terms of its prevalence and effects. It has been reported as a common ecto-parasite of both wild and farmed salmon at sea.

Returning wild salmon have been found to carry an average of 10 or more adult egg bearing females on their return to the Irish coastline (Copley *et al.,* 2005*;* Jackson *et al.,* 2013a) from their feeding grounds in the Atlantic. Having evolved their relationship with salmon and trout over many millennia, the parasite is well adapted to target its host species and it is ubiquitous to all the coastal waters around Ireland and indeed throughout the range of the Atlantic salmon (Jackson *et al.*, 2013b).

Salmon, whether wild or cultured, go to sea from fresh water free of sea lice and only pick up the infestation after they enter the marine phase of their lives. Sea lice infestations can inflict damage to their hosts through their feeding activity on the outside of the host's body by affecting the integrity of the fish’s epithelium, which impairs its osmoregulatory ability and leaves the fish open to secondary infections. In extreme cases this can lead to a reduced growth rate and an increased morbidity in affected individuals.

Marine finfish farms are perceived by certain sectors to be problematic because of the proximity of some operations to river mouths and a concern over the possible impact on wild migratory salmonid fisheries through infestation with sea lice. The studies on the impacts of lice infestation on smolts (Jackson *et al.* 2011, 2013a) suggest that sea lice induced mortality on outwardly migrating smolts is likely a minor and irregular component of marine mortality in the stocks studied. This conclusion is further supported by the finding of no correlation between the presence of aquaculture and the performance of adjacent wild salmon stocks.

Parasite Management: Based on the evidence from targeted studies, the information collected as part of the National Sea Lice Monitoring and Control Programme, scientific reports published by the Marine Institute, and in-line with external advice, it is concluded that there is a robust and effective management programme in place in Ireland to control sea lice infestation on farmed fish. Furthermore, there is no empirical evidence to support the suggestion that the fisheries are being adversely affected by unusual levels of sea lice infestation, whether of farmed origin or from other sources.

Table 4: Potential indicative environmental pressures of aquaculture activities within the qualifying interests (Large shallow inlets and bays (1160), Reefs (1170) and Submerged or partially submerged seacaves (8330)) of the Kenmare River SAC.

Activity	Pressure category	Pressure	Potential effects	Equipment	Duration (days)	Time of year	Factors constraining the activity
Aquaculture							
Rope Mussel and other suspended culture methods	Physical	Current alteration	Baffling effect resulting in a slowing of currents and increasing deposition onto seabed changing sedimentary composition	Floats, longlines, continuous ropes (New Zealand system) and droppers	365	All year	Location (sheltered location for year round activity)
	Biological	Organic enrichment	Faecal and pseudofaecal deposition on seabed potentially altering community composition. Drop-off of culture species.				
		Shading	Prevention of light penetration to seabed potentially impacting light sensitive species				
		Fouling	Increased secondary production on structures and culture species. Increased nekton production				
		Seston filtration	Alteration of phytoplankton and zooplankton communities and potential impact on carrying capacity				
		Nutrient exchange	Changes in ammonium and Dissolved inorganic nitrogen				

Activity	Pressure category	Pressure	Potential effects	Equipment	Duration (days)	Time of year	Factors constraining the activity
			resulting in increased primary production. Nitrogen (N_2) removal at harvest.				
		Alien species	Introduction of non-native species with culture organism transported into the site				
Intertidal Oyster Culture	Physical	Current alteration	Structures may alter the current regime and resulting increased deposition of fines or scouring.	Trestles and bags and service equipment	365	All year	At low tide only
		Surface disturbance	Ancillary activities at sites, e.g. servicing, transport increase the risk of sediment compaction resulting in sediment changes and associated community changes.				
		Shading	Prevention of light penetration to seabed potentially impacting light sensitive species				
	Biological	Non-native species introduction	Potential for non-native species (*C. gigas*) to reproduce and proliferate in SAC. Potential for alien species to be included with culture stock (hitch-hikers).				
		Disease risk	In event of epizootic the ability to manage disease in uncontained subtidal oyster				

Activity	Pressure category	Pressure	Potential effects	Equipment	Duration (days)	Time of year	Factors constraining the activity
			populations is compromised.				
		Organic enrichment	Faecal and pseudofaecal deposition on seabed potentially altering community composition				
Subtidal Shellfish culture	Physical	Surface disturbance	Abrasion at the sediment surface and redistribution of sediment	Dredge	Once quarterly	Seasonal	Weather for site access. Size of shellfish and market constraints
		Shallow disturbance	Sub-surface disturbance to 25mm				
	Biological	Monoculture	Habitat dominated by single species and transformation of infaunal dominated community to epifaunal dominated community.				
		By-catch mortality	Mortality of organisms captured or disturbed during the harvest or process, damage to structural fauna of reefs				
		Non-native species introduction	Potential for alien species to be included with culture stock (hitch-hikers)				
		Disease risk	In event of epizootic the ability to manage disease in uncontained subtidal shellfish populations would likely be compromised. The risk				

Activity	Pressure category	Pressure	Potential effects	Equipment	Duration (days)	Time of year	Factors constraining the activity
			introduction of disease causing organisms by introducing seed originating from the 'wild' in other jurisdictions				
		Nutrient exchange	Increased primary production. N_2 removal at harvest or denitrification at sediment surface.				
Salmon	Biological	Nutrient exchange	Increased primary production. N_2 removal at harvest or denitrification at sediment surface.		365		Fallow periods when no fish in the cages in the water.
		Organic enrichment	Faecal and waste food on seabed potentially altering community composition		365		
		Disease risk	Transmission of diseases and parasites between culture organisms and wild stocks and vice-versa.		365		
		Shading	Prevention of light penetration to seabed potentially impacting light sensitive species	Cages	365		Fallow periods when no fish in the cages in the water. Netting generally removed.

Aquaculture and Harbour Seal Interactions: In relation to Harbour seals (*Phoca vitulina*), less information is available on the potential interactions between the species and the activities in question (see NRC 2009). There has been no targeted research conducted in similar ecosystems that has directly assessed the impact of this type of aquaculture on harbor seals or indeed any other seal populations. There has, however, been considerable research on short-term responses of harbor seals to disturbance from other sources, and these can be used to inform assessments the potential impacts of disturbance from aquaculture activities currently underway and proposed in Kenmare River SAC. These disturbance studies have focused on impacts upon groups of seals that are already ashore at haul-out sites. Sources of potential disturbance have varied widely, and include people and dogs (Allen *et al.*, 1984; Brasseur & Fedak, 2003), recreational boaters (Johnson & Acevedo-Gutierrez, 2007; Lelli & Harris, 2001; Lewis & Mathews, 2000), commercial shipping (Jansen et al., 2006), industrial activity (Seuront & Prinzivalli, 2005) and aircraft (Perry et al., 2002). A harbor seal's response to disturbance may vary from an increase in alertness, movement towards the water, to actual entering into the water, i.e. flushing (Allen et al., 1984) and is typically governed by the location and nature of the disturbance activity. For example, kayaks may elicit a stronger response than power boats (Lewis & Mathews, 2000; Suryan & Harvey, 1999), and stationary boats have been shown to elicit a stronger response than boats moving along a predictable route (Johnson & Acevedo-Gutierrez, 2007). Furthermore, the mean distance at which seals are flushed into the water by small boats and people ranges between 80m and 530m, with some disturbances recorded at distances of over 1000m. In certain areas, these empirical studies have been used to inform management actions in marine protected areas, for example where a 1.5km buffer is set around harbor seal haul-out sites in the Dutch Wadden Sea to exclude recreational disturbance (Brasseur & Fedak, 2003).

Displacement from areas may also result from disturbances attributable to the activities of mariculture workers (Becker et al., 2009; 2011). This disturbance may be caused directly by the presence of workers on intertidal areas. However while disturbance from shellfish culture operations have been observed to influence the distribution of seal within a sheltered embayment, no inference was made on the effect on broader population characteristics of harbour seals from this study (Becker 2011).

Potential interactions between shellfish culture and marine mammals are broadly summarized in Table 5. It should be noted that direct demonstrations of these impacts are rare, and in most cases, potential effects are therefore predicted from the best existing information (NRC, 2010). Furthermore, none of the studies published to explore impacts on marine mammals and in particular Harbour Seals, were specifically designed to detect ecological impacts on this species (NRC 2009; Becker *et al*., 2009, 2011). Even where studies have been carried out around shellfish farms, uncertainty over spatial and temporal variation in both the location of structures (Watson-Capps and Mann, 2005) and levels of disturbance (Becker *et al*., 2009; 2011) constrain the conclusions that can be drawn about the impacts of mariculture on critical life functions such as reproduction and foraging.

Mariculture operations are considered a source of marine litter (Johnson, 2008). Ingestion of marine litter has also been shown to cause mortality in birds, marine mammals, and marine turtles (Derraik, 2002).

Mariculture structures can provide shelter, roost, or haul-out sites for birds and seals (Roycroft *et al*., 2004). This is unlikely to have negative effects on bird or seal populations, but it may increase the likelihood that these species cause faecal contamination of mollusc beds.

Seal interactions with marine finfish cages have been described (Aquaculture Stewardship Council, 2012). The seals (as predators) are attracted to the structures and their contents and have been known to tear netting in attempts to acquire prey items (i.e. cultured finfish). While a risk of entanglement in netting may present, it is not considered likely and the greatest risk is the escape of stocked fishes. In order to mitigate this risk, operators have resorted to the use of deterrent devices (Acoustic or Harassment) which have variable results based upon the location, extent of use and mammals targeted. However, deterrent devices are now considered detrimental to seals and alternative management actions are advised (Nelson 2004; Aquaculture Stewardship Council 2012). Therefore, careful stock management (density control and regular removal of mortalities from cages), use of seal blinds and appropriate net tensioning are all considered suitable methods to minimise negative interactions between seals and finfish culture. Lethal actions to remove seals are only allowed under licence, the criteria which are determined by NPWS (Section 42 of the Wildlife Act, 1976 (as amended).

The Kenmare River is deemed important both on a regional and on a national scale regarding its Harbour Seal population. The overall Harbour Seal numbers (population) has been stable or increasing between 2003 and 2012 (NPWS data) coincident with static levels of mariculture production. While no definitive conclusions can be drawn regarding the population status of harbour seals in the Kenmare River and more widely around Ireland, based upon survey reports from 2009-2011 (as no baseline reference values are provided), it would appear that the levels both regionally and nationally are stable or possibly increasing (see Figure 2 in NPWS 2012).

6.2 Fisheries

Fisheries using bottom contacting mobile gears cause physical abrasion and disturbance pressure to marine habitats in Kenmare River. These include bottom trawling on sedimentary habitats and dredging in mixed sediments and at the edge of reef for scallop. Pot fisheries and static net fisheries may cause localized abrasion and disturbance to habitats which may be significant for habitats that are highly sensitive to such pressures. All fisheries extract fish biomass which may reduce habitat quality for designated species such as otter and harbour seals. Harbour seals and otters may be caught as by-catch in certain gears such as pelagic trawls and trammel nets set for bait in shallow water.

6.3 In-combination activities

Other activities leading to potential impacts on conservation features relate to harvest of seaweed on intertidal reef communities. There is little known concerning the level of harvest from these intertidal reef communities. The impact is likely two-fold, direct impact upon the reefs by removal of a constituent species and impact upon intertidal sediments as a consequence of travel across the shore to the harvest sites.

Seal watching cruises are conducted in Kenmare. Given the nature of this activity it is unlikely that they will result in extensive disturbance to seal species.

There are a number of activities which are terrestrial in origin that might result in impacts on the conservation features of the Kenmare River SAC. Primary among these are point source discharges from municipal and industrial units (Shellfish Pollution Reduction Programme, DECLG). There are five urban waste water treatment plants in the general vicinity of the SAC. These are found in Ardgroom, Kenmare, Sneem, Kilgarvan, Eyeries. The pressure derived from these facilities is a discharge that may impact upon levels of dissolved nutrients, suspended solids and some elemental components e.g. aluminium in the case of water treatment facilities.

Table 5: Potential interactions between aquaculture activities and the Annex II species Harbour Seal (*Phoca vitulina*) within the Kenmare River SAC.

Culture Method	Pressure category	Pressure	Potential effects	Equipment	Duration (days)	Time of year	Factors constraining the activity
All Aquaculture Methods	Physical	Habitat Exclusion	Structures may result in a barrier to movement of seals.	Net pens, Bags and trestles	365	All year	Spatial extent and location of structures used for culture.
		Disturbance	Ancillary activities at sites increase the risk of disturbance to seals at haul out sites (resting, breeding and/or moulting) or in the water.	Site services, human, boat and vehicular traffic	365	All year	Seasonal levels of activity relating to seeding, grading, and harvesting. Peak activities do no coincide with more sensitive periods for seals (i.e. pupping and moulting)
		Entanglement	Entanglement of seals from ropes or material used on structures or during operation of farms	Trestles, bags, ropes and/or nets used in day to day	365	All year	Farm management practices
		Ingestion	Ingestion of waste material used on farm	Ties used to secure bags and secure bags to trestle	365	All year	Farm management practices
		Deterrent Methods	Seals interfering with cages will result in deterrent actions, e.g. use of Acoustic deterrent or harassment Devices. If all non lethal avenues fail then lethal methods may be employed (under licence).	ADDs and lethal devices (shooting)	365		Fallow periods no fish on-site

Table 6: Potential pressures caused by fisheries in the Kenmare River SAC.

METIER/ ACTIVITY	PRESSURE CATEGORY	PRESSURE	POTENTIAL EFFECTS	FISHING GEARS OR AQUACULTURE EQUIPMENT	DURATION (DAYS)	TIME OF YEAR	FACTORS CONSTRAINING THE ACTIVITY
Potting,for shrimps	Physical	Surface disturbance	Abrasion at the sediment surface	Shrimp pots	240	August to March	catch rate, weather, market
	Biological	Extraction	Removal of shrimp				
		By-catch	Mortality of species in by-catch				
Lobster and crab potting	Physical	Surface disturbance	Abrasion at the sediment surface	Soft eye side entrance creels and top entrance pots	Approx 240	Mainly March to October	catch rate, weather, market
	Biological	Extraction	Removal of lobster and crab				
		By-catch	Mortality of species in by-catch				
Tangle netting	Physical	Surface disturbance	Abrasion at the sediment surface	Tangle nets	Unknown	Mainly May to Sept	catch rate, weather,
	Biological	Extraction	Removal of crayfish and other commercial fish species				
		By-catch	Potential by-catch of designated species grey seal, porpoise and otter.				

METIER/ ACTIVITY	PRESSURE CATEGORY	PRESSURE	POTENTIAL EFFECTS	FISHING GEARS OR AQUACULTURE EQUIPMENT	DURATION (DAYS)	TIME OF YEAR	FACTORS CONSTRAINING THE ACTIVITY
Dredging for scallops	Physical	Surface disturbance	Abrasion at the sediment surface	Fixed toothed dredges (DRB), ICES code 04.1.1	unknown	Mainly winter and spring	catch rate, weather, market, spatial closures
		Shallow disturbance	Sub-surface disturbance to 25mm				
	Biological	Extraction	Removal of scallops				
		By-catch mortality	Mortality of organisms captured or disturbed during the fishing process, damage to structural fauna of reefs				
Midwater (pelagic) trawling	Biological	Extraction	Removal of pelagic fish (Herring and sprat)	Pelagic trawls, OTM, ICES 03.2.1.	Unknown	Sept to March	Fish biomass
		By-catch	Potential by-catch of designated species harbour seal and otter.				
Hook and line pelagic	Biological	Extraction	Removal of pelagic and demersal fish	Hooks and lines, LHP, ICES 09.1.0, LHM, ICES 09.2.0, LTL, ICES 09.6.0	Unknown	Summer, Autumn	Quota, weather
Bottom set tangle nets	Physical	Surface disturbance	Abrasion at the sediment surface	Gill nets, GNS, ICES 07.1.0	Unknown	All year	weather

METIER/ ACTIVITY	PRESSURE CATEGORY	PRESSURE	POTENTIAL EFFECTS	FISHING GEARS OR AQUACULTURE EQUIPMENT	DURATION (DAYS)	TIME OF YEAR	FACTORS CONSTRAINING THE ACTIVITY
	Biological	Extraction	Removal of demersal fish				
		By-catch	Potential by-catch of designated species harbour seal and otter.				
Mixed fisheries demersal trawling	Physical	Surface disturbance	Abrasion at the sediment surface	Demersal single bottom otter trawls (OTB, ICES code 03.1.2	Unknown	All year	Weather, quota restrictions
		Shallow disturbance	Sub-surface abrasion by trawl doors				
	Biological	Extraction	Removal of fish				
		By-catch mortality	Mortality of organisms in contact with fishing gear				
Trammel nets (bait fishery)	Physical	Surface disturbance	Abrasion on sediment surface or on reefs	GTR, ICES 07.5.0	Unknown	All year	Availability and price of bait
	Biological	Extraction	Removal of non-commercial fish species				
		By catch	Potential catch of designated species otter and harbour seal				

7. Screening of Aquaculture Activities

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

In this assessment screening of the qualifying interests against the proposed activities is based primarily on spatial overlap i.e. if the qualifying interests overlap spatially with the proposed activities then significant impacts due to these activities on the conservation objectives for the qualifying interests is not discounted (not screened out) except where there is absolute and clear rationale for doing so. Where there is relevant spatial overlap full assessment is warranted. Likewise if there is no spatial overlap and no obvious interaction is likely to occur, then the possibility of significant impact is discounted and further assessment of possible effects is deemed not to be necessary. Table 2 provides spatial overlap extent between designated habitat features and aquaculture activities within the qualifying interests of the Kenmare River SAC.

7.1 Aquaculture Activity Screening

- The marine habitat Submerged or Partially Submerged Seacaves (8330) has no spatial overlap with (existing and proposed) aquaculture activities.
- Table 2 highlights the spatial overlap between (existing and proposed) aquaculture activities and both habitat features (i.e. Large Shallow Inlet and Bay and Reefs).
- Tables 6 and 7 provide an overview of overlap of aquaculture activities and specific community types (identified from Conservation Objectives) within the broad habitat features 1160 and 1170, respectively.

Where the overlap between an aquaculture activity and a feature is zero it is screened out and not considered further. Therefore, the feature **Submerged or partially submerged sea caves (8330)** is excluded from further consideration in this assessment.

Furthermore, if the aquaculture activity occurs within the SAC but does not overlap a keystone community[8] habitat type or overlap with a feature of interest then they are excluded from further assessment.

Therefore, the following habitats and one species are also excluded from further consideration in this assessment:

- **1014 Marsh Snail *Vertigo angustior***
- **1303 Lesser Horseshoe Bat *Rhinolophus hipposideros***

[8] NPWS 2013. Kenmare River SAC (site code: 2158)-Conservation objectives supporting document - Marine habitats and species. Version 1 March 2013

- **1220 Perennial vegetation of stony banks**
- **1230 Vegetated sea cliffs of the Atlantic and Baltic coasts**
- **1330 Atlantic salt meadows (Glauco-Puccinellietalia maritimae)**
- **1410 Mediterranean salt meadows (*Juncetalia maritimi*)**
- **2120 Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes")**
- **2130 Fixed coastal dunes with herbaceous vegetation (grey dunes)**
- **4030 European dry heaths**
- **6130 Calaminarian grasslands of the *Violetalia calaminariae***

Furthermore, of the 11 community types (see Table 1) listed under the two habitat features (1160 and 1170), two (**Intertidal Mobile Sand Community Complex and Shingle**) have no spatial overlap between them and any aquaculture activities. In one instance, the community type **Shingle** appears to overlap with subtidal scallop aquaculture; however, this is considered a mapping anomaly and therefore, the spatial overlap is concluded as nil. On this basis, the community types, **Intertidal Mobile Sand Community Complex** and **Shingle** are excluded from further analysis of aquaculture interactions.

A number of aquaculture operations and applications within **Ardgroom Harbour and Killmackillogue Harbour** that do not overlap with features of interest and/or keystone communities are excluded from further analysis and are considered not to have a significant impact on habitat conservation features.

When overlap was observed it was quantified in a GIS application and presented on the basis of coverage of specific activity (representing different pressure types), licence status (licenced or application) intersecting with designated conservation features and/or sub-features (community types).

Table 6: Habitat utilisation i.e. spatial overlap in hectares and percentage (given in parentheses) of aquaculture activity over community types within the qualifying interest 1160 - Large shallow inlets and bays (Spatial data based on licence database provided by DAFM. Habitat data provided in NPWS 2013a. 2013b).

				1160 – Large shallow inlets and bays								
Culture Type	Location	Method	Status	Coarse sediment dominated by polychaetes comm. complex	Fine to medium sand with crustaceans and polychaetes comm. complex	Intertidal reef comm. complex	*Laminaria* dominated comm. complex	Muddy fine sands dominated by polychaetes and *Amphiura filiformis* comm. complex	Subtidal reef with echinoderms and faunal turf comm. complex	*P. multiplicatus* comm. complex	Maerl	*Zostera*
Mussel (*Mytilus edulis*) on ropes	Subtidal	I	L	0.02 (2.88E-04)	5.68 (0.29)	0.03 (5.05E-03)	13.44 (0.4)	4.29 (0.02)	0	0	0	0
Mussel (*Mytilus edulis*) on ropes	Subtidal	I	A	275.01 (3.31)	47.24 (2.38)	0	32.02 (0.95)	20.07 (0.10)	94.95 (1.98)	0	0	0
Scallops (*Pecten maximus*) on seabed	Subtidal	I	L	37.90 (0.46)	20.17 (1.01)	1.03 (0.20)	198.93 (5.93)	186.13 (0.92)	9.15 (0.19)	6.23 (100.00)	13.06 (27.89)	0.50 (2.52)
Scallops (*Pecten maximus*) on seabed	Subtidal	I	A	0.47 (0.01)	0	0.01 (1.99E-03)	1.39 (0.04)	0	8.97E-04 (1.86672E-05)	0	0	0
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	I	L	0	0	0.80 (0.15)	0.71 (0.02)	5.99 (0.03)	0.03 (5.88E-04)	0	0	0
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	I	A	0	4.15 (0.21)	0	10.22 (0.30)	0	1.66 (0.03)	0	0	0
Salmon (*Salmo salar*) in net pens	Subtidal	I	L	46.28 (0.56)	4.28 (0.22)	0	5.50 (0.16)	0	6.62 (0.14)	0	0	0
Salmon (*Salmo salar*) in net pens	Subtidal	I	A	0	1.71 (0.09)	0	4.58 (0.14)	15.68 (0.08)	9.92 (0.21)	0	0	0
Totals				**359.68 (4.33)**	**83.23 (4.18)**	**2.67 (5.07)**	**267.5 (7.96)**	**238.15 (1.18)**	**122.36 (2.54)**	**6.23 (100.00)**	**13.06 (27.89)**	**0.50 (2.52)**

Table 7: Habitat utilisation i.e. spatial overlap in hectares and percentage (given in parentheses) of Aquaculture activity over community types within the qualifying interest 1170 - Reefs (Spatial data based on licence database provided by DAFM. Habitat data provided in NPWS 2013a, 2013b).

				1170 - Reefs		
Culture Type	Location	Method	Status	Intertidal reef community complex	*Laminaria* - dominated community complex	Subtidal reef with echinoderms and faunal turf community complex
Mussel (*Mytilus edulis*) on ropes	Subtidal	I	L	0.09 (0.01)	37.56 (1.02)	0
Mussel (*Mytilus edulis*) on ropes	Subtidal	I	A	0.03 (4.46E-03)	35.82 (0.97)	100.59 (2.08)
Scallops (*Pecten maximus*) on seabed	Subtidal	I	L	1.03 (0.15)	198.93 (5.41)	9.15 (0.19)
Scallops (*Pecten maximus*) on seabed	Subtidal	I	A	0.01 (1.54E-03)	1.84 (0.05)	8.97E-04 (1.8553E-05)
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	I	L	0.80 (0.12)	0.71 (0.02)	0.03 (5.84E-04)
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	I	A	1.47 (0.22)	12.10 (0.33)	1.66 (0.03)
Salmon (*Salmo salar*) in net pens	Subtidal	I	L	0	5.51 (0.15)	6.62 (0.14)
Salmon (*Salmo salar*) in net pens	Subtidal	I	A	0	4.58 (0.12)	9.92 (0.21)
Total				**3.43 (0.51)**	**297.05 (8.07)**	**127.97 (2.65)**

8. Assessment of Aquaculture Activities

8.1 Determining significance

The significance of the possible effects of the proposed activities on habitats, as outlined in the Natura Impact Statement (Section 6) and subsequent screening exercise (Section 7), is determined here in the assessment. The significance of effects is determined on the basis of Conservation Objective guidance for constituent habitats and species (Figures 1, 2 and NPWS 2013a, 2013b).

Within the Kenmare River SAC the qualifying habitats/species considered subject to potential disturbance and therefore, carried further in this assessment are:

- 1160 Large shallow inlets and bays
- 1170 Reefs
- 1355 Otter - *Lutra lutra*
- 1365 Common (Harbour) seal - *Phoca vitulina*

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

- *Zostera* –dominated community
- Maerl – dominated community
- *Pachycerianthus multiplicatus* community

For broad habitats and community types (Figures 1 and 2) significance of impact is determined in relation to, first and foremost, spatial overlap (see Section 7; Tables 6 and 7). Subsequent disturbance and the persistence of disturbance are considered as follows:

1. <u>The degree to which the activity will disturb the qualifying interest.</u> By disturb is meant change in the characterising species, as listed in the Conservation Objective guidance (NPWS 2013b) for constituent communities. The likelihood of change depends on the sensitivity of the characterising species to the activities in question. Sensitivity results from a combination of intolerance to the activity and/or recoverability from the effects of the activity (see Section 8.2 below).

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

3. <u>The area of communities or proportion of populations disturbed.</u> In the case of community disturbance (continuous or ongoing) of more than 15% of the community area it is deemed

to be significant. This threshold does not apply to sensitive habitats as listed above (*Zostera*, Maerl) where any spatial overlap of activities should generally be avoided.

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

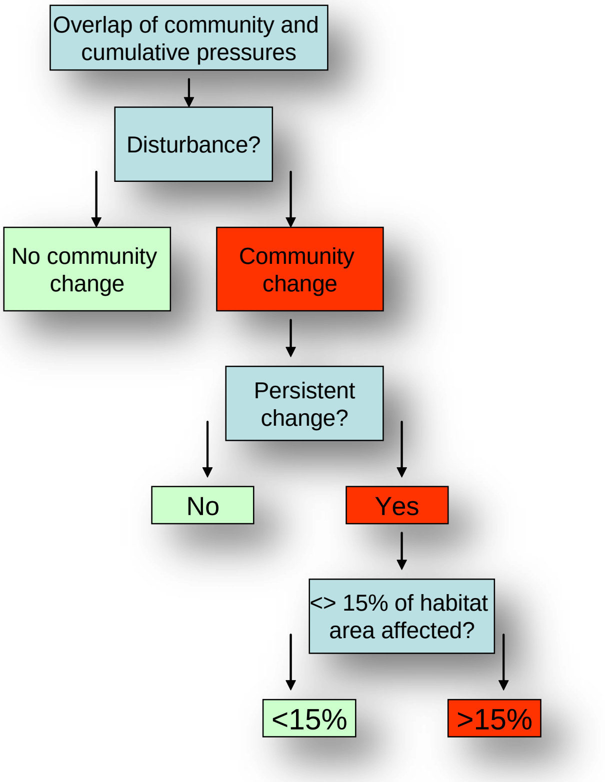

Figure 12: Determination of significant effects on community distribution, structure and function for sedimentary habitats (following NPWS 2013b).

In relation to designated species (Harbour Seal, Otter) the capacity of the population to maintain itself in the face of anthropogenic induced disturbance or mortality at the site will need to be taken into account in relation to the Conservation Objectives (CO's) on a case by case basis.

8.2 Sensitivity and Assessment Rationale

This assessment used a number of sources of information in assessing the sensitivity of the characterising species of each community recorded within the habitat features of the Kenmare River SAC. One source of information is a series of commissioned reviews by the Marine Institute which identify habitat and species sensitivity to a range of pressures likely to result from aquaculture and fishery activities (ABPMer 2013a-h). These reviews draw from the broader literature, including the MarLIN Sensitivity Assessment (Marlin.ac.uk) and the AMBI Sensitivity Scale (Borja et al., 2000) and other primary literature. It must be noted that NPWS have acknowledged that given the wide range of community types that can be found in marine environments, they application of conservation targets to these would be difficult (NPWS 2013b). On this basis, they have proposed broad community complexes as management units. These complexes (for the most part) are very broad in their description and do not have clear surrogates which might have been considered in targeted studies and thus reported in the scientific literature. On this basis, the confidence assigned to likely interactions of the community types with anthropogenic activities are by necessity relatively low, with the exception of community types dominated by sensitive taxa, e.g. Mearl and *Zostera*. Other literature cited in the assessment does provide a greater degree of confidence in the conclusions. For example, the output of a recent study has provided greater confidence in terms of assessing likely interactions between intertidal oyster culture and community types (Forde et al submitted). Sensitivity of a species to a given pressure is the product of the intolerance (the susceptibility of the species to damage, or death, from an external factor) of the species to the particular pressure and the time taken for its subsequent recovery (recoverability is the ability to return to a state close to that which existed before the activity or event caused change). Life history and biological traits are important determinants of sensitivity of species to pressures from aquaculture.

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

- For persistent pressures i.e. activities that occur frequently and throughout the year recovery capacity may be of little relevance except for species/communities that may have extremely rapid (days/weeks) recovery capacity or whose populations can reproduce and recruit in balance with population damage caused by aquaculture. In all but these cases and if sensitivity is moderate or high then the species/habitats may be negatively affected and will exist in a modified state. Such interactions between aquaculture and species/habitat/community represent persistent disturbance. They become significantly disturbing if more than 15% of the community is thus exposed (NPWS 2013a).
- In the case of episodic pressures i.e. activities that are seasonal or discrete in time both the intolerance and recovery components of sensitivity are relevant. If sensitivity is high but recoverability is also high relative to the frequency of application of the pressure then the species/habitat/community will be in favourable conservation status for at least a proportion of time.

The sensitivities of the community types (or surrogates) found within the Kenmare River SAC to pressures similar to those caused by aquaculture (e.g. smothering, organic enrichment and physical disturbance) are identified in Table 8. The sensitivities of species which are characteristic (as listed in the Conservation Objective supporting document) of benthic communities to pressures similar to those caused by aquaculture (e.g. smothering, organic enrichment and physical disturbance) are identified, where available, in Table 9. The following guidelines broadly underpin the analysis and conclusions of the species and habitat/community type sensitivity assessment:

- Sensitivity of certain taxonomic groups such as emergent sessile epifauna to physical pressures is expected to be generally high or moderate because of their form and structure (Roberts *et al.* 2010). Also high for those with large bodies and with fragile shells/structures, but low for those with smaller body size. Body size (Bergman and van Santbrink 2000) and fragility are regarded as indicative of a high intolerance to physical abrasion caused by fishing gears (i.e. dredges). However, even species with a high intolerance may not be sensitive to the disturbance if their recovery is rapid once the pressure has ceased.
- Sensitivity of certain taxonomic groups to increased sedimentation is expected to be low for species which live within the sediment, deposit and suspension feeders; and high for those sensitive to clogging of respiratory or feeding apparatus by silt or fine material.
- Recoverability of species depends on biological traits (Tillin *et al.* 2006) such as reproductive capacity, recruitment rates and generation times. Species with high reproductive capacity, short generation times, high mobility or dispersal capacity may maintain their populations even when faced with persistent pressures; but such environments may become dominated by these (r-selected) species. Slow recovery is correlated with slow growth rates, low fecundity, low and/or irregular recruitment, limited dispersal capacity and long generation times. Recoverability, as listed by MarLIN, assumes that the impacting factor has been removed or stopped and the community type returned to a state capable of supporting the species or community in question. The recovery process is complex and therefore the recovery of one species does not signify that the associated biomass and functioning of the full ecosystem has recovered (Anand & Desrocher, 2004) cited in Hall *et al*., 2008).,

8.3 Assessment of the effects of aquaculture production on the Conservation Objectives for habitat features in the Kenmare River SAC.

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

The constituent communities identified in the Annex 1 feature, **Large Shallow Inlets and Bays (1160)**) are:

1. Intertidal mobile sand community complex (No overlap with aquaculture)
2. *Zostera*-dominated community
3. Maerl-dominated community
4. *Pachycerianthus multiplicatus* community
5. Muddy fine sands dominated by polychaetes and *Amphiura filiformis* community complex
6. Fine to medium sand with crustaceans and polychaetes community complex
7. Coarse sediment dominated by polychaetes community complex

8. Shingle (No overlap with aquaculture)
9. Intertidal reef community complex
10. *Laminaria*-dominated community complex
11. Subtidal reef with echinoderms and faunal turf community complex

For Large Shallow Inlets and Bays (1160) there are a number of attributes (with associated targets) relating to this habitat feature as well as its constituent community types;

1. **Habitat Area** – it is unlikely that the activities proposed will reduce the overall extent of permanent habitat within the feature Large Shallow Inlet and Bays. The habitat area is likely to remain stable.
2. **Community Distribution - (conserve a range of community types in a natural condition).**

   This attribute considered interactions with 8 of the community types listed above and exclude three sensitive communities (i.e., *Zostera*-dominated community, Maerl-dominated community and *Pachycerianthus multiplicatus* community). Of the 8 communities, 2 have no overlap with aquaculture activities. Therefore, the following 6 community types, found within the qualifying interest 1160 of the SAC have overlap with aquaculture activities:

   1. Muddy fine sands dominated by polychaetes and *Amphiura filiformis* community complex
   2. Fine to medium sand with crustaceans and polychaetes community complex
   3. Coarse sediment dominated by polychaetes community complex
   4. Intertidal reef community complex
   5. *Laminaria*-dominated community complex
   6. Subtidal reef with echinoderms and faunal turf community complex

   The community types listed above will be exposed to differing ranges of pressures from aquaculture activities. Some of these may result in more chronic and long term changes in community composition which were considered during the assessment process. Such activities in dredging for scallop which will result in physical disturbance to infanal communities and longline mussel culture and finfish farming which results in organic loading on the seabed resulting in biogeochemical changes to sediment and a likely change in faunal compositions – whether this results in permanent change to the community type is unclear. Table 8, where possible, lists the community types (or surrogates) and Table 9 lists the constituent taxa and both provide a commentary of sensitivity to a range of pressures. The risk scores in Table 8 and 9 are derived from a range of sources identified above. The pressures are listed as those likely to result from the primary aquaculture activities carried out in the Kenmare River SAC. Aquaculture activities in the Kenmare River SAC comprises of both finfish and shellfish production. Considered in the assessment are intertidal oyster culture (bag and trestle), subtidal scallop on-bottom culture, intertidal clam on-bottom culture, subtidal (suspended) rope mussel culture, and Atlantic salmon culture in net pens.

Table 11 below identify the likely interactions between the relevant aquaculture activities and the broad habitat feature (1160) and their constituent community types, with a broad conclusion and justification on whether the activity is considered disturbing to the feature in question. It must be noted that the sequence of distinguishing disturbance is as highlighted above, whereby activities with spatial overlap on habitat features are assessed further for their ability to cause persistence disturbance on the habitat. If persistent disturbance is likely then the spatial extent of the overlap is considered further. If the proportion of the overlap exceeds a threshold of 15% disturbance of the habitat (or each constituent community type) then any further licencing should be informed by interdepartmental review and consultation (NPWS 2013b). While some activities (e.g. suspended mussel culture, intertidal clam culture and salmon cage culture) might result in long-term change to the 6 community types indentified above; in all cases, no activity (individually or combined) extends beyond 15% of the community type (Tables 6 and 11). In addition, combined activities listed overlap with 2.69% of habitat feature (1160) Large Shallow Inlet and Bay (Table 3). On the basis of targeted research (Forde et al, Submitted) and the fact that intertidal oyster culture on trestles is considered non-disturbing to both sedimentary communities and intertidal reef communities, further assessment (i.e. spatial analysis) is not required.

3. **Community Extent and Structure – focusing upon Mearl, *Zostera* and *Pachycerianthus multiplicatus* communities**

The focus of these attributes are primarily upon the 3 community types, *Zostera*-dominated community, Maerl-dominated community and *Pachycerianthus multiplicatus* community. These communities are considered highly diverse and sensitive community types which host a wide range of taxa. The ‘keystone’ species in each community type (Maerl and *Zostera*) is considered important and sensitive in their own right. It should be noted that maerl beds exist within Ardgroom and Killmakilloge Harbours, which are not within the qualifying interest (i.e. 1160 Large shallow inlets and bays or 1170 Reefs). However, as these maerl beds are still within the SAC boundary and are listed in Annex V of the Habitats Directive they must be afforded protection and maintained in favourable conservation status.

The Kenmare River is one of a very small number of sites within Europe where the large tube building anthozoan *Pachycerianthus multiplicatus* is known to occur. This community is found in coarse sediment dominated by a polychaete community complex. The anthozoan itself resides in a large tube which is known to provide a variety of micro niches thus resulting in localised increases in biodiversity. *P. multiplicatus* is listed in the UK Biodiversity Action Plan as a species of conservation concern (Biodiversity Steering Group, 1995). According to (Wilding & Wilson, 2009) the species is deemed nationally rare, and due to its limited, fragmented distribution, populations are likely to be of global importance.

Given the highly sensitive natures of these community types and constituent taxa (Table 8 and 9) it is highly likely that aquaculture activities of any type which overlap these community type and the pressures may result in long-term or permanent change to the extent of these community types and the impact upon their structure and function cannot be discounted. This effect will come about by the physical removal or damage caused by the activities on any of the highly diverse taxa associated with these community types (Table 11). In addition, the impact of the placement of large numbers of scallop seed on seagrass beds and subsequent harvest by scuba diving is uncertain, in the absence of information on the nature of the diving operation (exact method of extraction).

The constituent communities identified in the Annex 1 feature **Reefs (1170)** are:

1. Intertidal reef community complex
2. *Laminaria*-dominated community complex
3. Subtidal reef with echinoderms and faunal turf community complex

Similar to Large Shallow Inlets and Bays (1160) there are a number of attributes (with associated targets) relating to Reef (1170) habitat features as well as associated constituent community types;

1. **Distribution and Habitat area:** The aquaculture activities in question will not, by virtue of the pressures associated with them, impact on the broad distribution of reef structures and reduce the area of these features within the SAC.
2. **Community Structure:** The intertidal reef community, which is extensive within the SAC, is dominated by brown algal species with red algae and a faunal aspect typical of the rocky intertidal (i.e. gastropods, anemones and sponges). The subtidal rocky communities are dominated by large macro algae (kelp) and faunal turf (anthozoans, echinoderms, hydrozoans and sponges).

   Table 8 lists the community (or surrogates) and Table 9 lists the constituent taxa and both provide a commentary of sensitivity to a range of pressures. The risk scores are derived from a range of sources identified above. The pressures are listed as those likely to result from the primary aquaculture activities carried out in the Kenmare River SAC. Aquaculture activities in the Kenmare River SAC comprises of both finfish and shellfish production. Considered in the assessment are intertidal oyster culture (bag and trestle), subtidal scallop on-bottom culture, intertidal clam on-bottom culture, subtidal (suspended) rope mussel culture, and Atlantic salmon culture in net pens.

   Suspended culture activities of finfish and rope mussel can lead to organic enrichment and exclusion of taxa on any reef community type (as well 1170), thus impacting upon community structure and hence, function. In addition, scallop culture on the seabed is unlikely to occur on the majority of reef community types, but may occur on more mixed sediments. However, the maximum cover of aquaculture activities on each of the habitats is below 15% (Table 13) and the total cover of all aquaculture activities is 4.48% of reef habitat (1170) (Table 3).

Introduction of non-native species; As already outlined **o**yster culture may present a risk in terms of the introduction of non-native species as the Pacific oyster (*Crassostrea gigas*) itself is a non-native species. Recruitment of *C. gigas* has been documented in a number of Bays in Ireland and appears to have become naturalised (i.e. establishment of a breeding population) in two locations (Kochmann et al 2012; 2013) and may compete with the native species for space and food. In addition to having large number of oysters in culture, Kochmann et al (2013) identified short residence times and large intertidal areas as factors likely contributing to the successful recruitment of oysters in Irish bays. In addition, a recent study (Kochmann and Crowe, 2014) has identified heavy macroalgal cover as a potential factor governing successful recruitment, with higher cover resulting in lower recruitment. Oyster production in the Kenmare does not fulfil these criteria, as production is low (30 tonnes pa), the suitable habitat intertidally is low with high macroalgal cover and residence time is between 1.2-22.6 days. Therefore the risk of successful establishment of the pacific oyster in Kenmare River SAC is considered low.

In relation to the Manila clam (*Ruditapes philippinarum*), this species has been in culture in Ireland since 1984 and, to the best of our knowledge, no recruitment in the wild has been recorded. The operations are totally reliant on hatchery seed and are fully contained at all stages of the production cycle. The risk of naturalisation of this species is considered low, but should be kept under surveillance.

Table 8: Matrix showing, where possible, the characterising community types (or surrogates) sensitivity scores x pressure categories in Kenmare River SAC (ABPMer 2013a-h). Table 9 provides the code for the various categorisation of sensitivity and confidence

	Pressure Type																						
Community Type (EUNIS code)	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Extraction	Siltation (addition of fine sediments, pseudofaeces, fish food)	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments-sedimentation	Increased removal of primary production-phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
Zostera-dominated community (A5.533)	M-H (***)	M-VH (***)	M-VH (***)	M-VH (***)	VH (***)	VH (***)	M(*)	M (***)	M(*)	H (***)	NS (*)	H (***)	H (***)	NS (*)	H-VH (*)	H-VH (*)	H (**)	NS (*)	NS (*)	NEv	NEv	NS (***)	H-VH (**)
Maerl-dominated community (A5.51)	H (***)	H-VH (***)	H (***)	H-VH (***)	H-VH (***)	H-VH (***)	NS (*)	NS (*)	NS (*)	H(*)	NS (*)	H(*)	H (***)	NS (*)	H(**)	H(**)	H (***)	VH (***)	NS (*)	NE	NE	NE	VH (*)
Muddy fine sands dominated by polychaetes and *A. filiformis* community complex (Subtidal A5.33/A5.35)	NS (*)	L(*)	L(*)	L-M (*)	L(*)	L-M (*)	L-M (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L(*)	NS (*)	L(*)	L(*)	H (*)	NS (*)	NS (*)	NS (*)	NS (*)	L(*)	NS (*)
Fine to medium sand with crustaceans and polychaetes community complex (Intertidal and subtidal) (A5.23)	NS (*)	L(*)	L(*)	L-M (*)	L-M (*)	L-M (*)	L-M (*)	M(*)	L-M (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L-NS (***)	L-NS (***)	NS (***)	NS (*)	NS (*)	NS (*)	NS (*)	L(*)	NS (*)

	Pressure Type																						
Community Type (EUNIS code)	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Extraction	Siltation (addition of fine sediments, pseudofaeces, fish food)	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments-sedimentation	Increased removal of primary production-phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
Intertidal reef community complex (A3.21)**	NS (*)	NA	NA	NA	NS (*)	M-VH (*)	NA	NA	NS (*)	NS (*)	NS (*)	NS (*)	NE	NS (*)	NE	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Laminaria-dominated community complex (A3.21)**	NS (*)	NA	NA	NA	NS (*)	M-VH (*)	NA	NA	NS (*)	NS (*)	NS (*)	NS (*)	NE	NS (*)	NE	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Subtidal reef with echinoderms and faunal turf community complex (A4.1/4.2)	NS (*)	NA	NA	NA	NS (*)	M-VH (*)	NA	NA	NS (*)	NS (*)	NS (*)	NS (*)	NE	NS (*)	NE	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)

Note: *No sensitivity listed for this community type;No sensitivity listed for this community type (3.21) so using scores for A3.22.**

Table 9: Matrix showing the characterising species sensitivity scores x pressure categories for taxa in Kenmare River SAC (ABPMer 2013a-h). Table 9 provides the code for the various categorisation of sensitivity and confidence

	Pressure Type																						
Species	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Extraction	Siltation	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments- sedimentation	Increased removal of primary production- phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
Abra alba	L(*)	L (***)	L(*)	M (*)	NS (***)	M (*)	L(*)	NS (*)	NS (*)	L(*)	L(*)	NS (*)	NS (*)	NS (*)	L (***)	L-M (***)	L-M (*)	NS (*)	NS (*)	NS (***)	NEv	L (***)	NS (*)
Alcyonium digitatum	L-M (***)	NE	NE	NE	L(**)	M(*)	NA	NA	L(*)	NS (*)	NS (*)	NEv	NE	NS (*)	NE	M(*)	NEv	NS (*)	NS (*)	NEv	NEv	NS (*)	NS (*)
Angulus sp. (Moerella)	NS (*)	L(*)	L (***)	M(*)	NS (*)	H(*)	M-H (*)	NS (*)	L-M (*)	L(*)	NS (*)	NS (*)	Nev	L-NS (*)	NEv	NEv	M (*)	NS (*)	NS (*)	NS (*)	NEv	NEv	NS (*)
Bathyporeia spp.	NS (*)	L (***)	L (***)	L-M (*)	L (***)	L-M (*)	L-M (*)	L-M (*)	NS (*)	NS (*)	NS (*)	L-M (*)	L-M (*)	NS (*)	L-M (***)	L-M (***)	L-M (*)	NS (*)	NS (*)	NS (*)	NEv	NEv	NS (*)
Corynactis viridis	M-H (*)	NA	NA	NA	L(*)	H-VH (*)	NA	NA	M-H (*)	L(*)	NS (*)	NS (*)	NE	NS (*)	NE	NEv	NS (*)	NS (*)	NS (*)	NEv	NEv	NEv	NS (*)
Cliona celata	M (***)	NA	NA	NE	M (**)	L(*)	NA	NA	NEv	NS (***)	NS (*)	NS (***)	NE	NS (*)	NE	NEv	NS (*)	NS (*)	NS (*)	NEv	NEv	NEv	NS (*)
Caryophyllia smithi	H (**)	NA	NA	NE	H (***)	VH(*)	NA	NA	NS (*)	NS (*)	H(*)	NEv	NE	NS (*)	NE	NEv	NEv	NS (*)	NS (*)	NEv	NEv	NEv	MS (*)
Capitella spp.	L(*)	L (**)	L (**)	L(*)	L(*)	NS (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	L (***)	L (***)	NS (*)	NS (*)	NS (*)	NS (***)	L (***)	NS (***)	NS (*)
Corophium volutator	L (***)	L (***)	L (***)	L(*)	L (***)	L (***)	M(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	L (***)	L (***)	Nev	NS (*)	NS (*)	NA	NEv	L (***)	NS (*)
Cerastoderma edule	L(*)	L-M (*)	L-M (***)	L-H (*)	L (***)	L-M (*)	L-H (*)	NS (*)	L(*)	NS (*)	NS (*)	NS (*)	NS (**)	L-NS (*)	L-M (*)	L-M (*)	M (*)	M (*)	NS (*)	NS (*)	NEv	L-M (*)	NS (*)

Species	Pressure Type																						
	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Extraction	Siltation	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments- sedimentation	Increased removal of primary production- phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
Echinus esculentus	L-M (***)	NA	NA	NA	L (***)	H(*)	NA	NA	NS (*)	NS	NS (*)	NS	NE	NS (*)	NE	H(***)	NS (*)	L-M	NS	NEv	NEv	M-H	NS (*)
Euclymene oerstedii	NS (*)	NS (*)	M(*)	H(*)	NS (*)	H(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	M(*)	M(*)	NS (*)	NS (*)	NS (*)	NS (*)	NEv	NS (*)	NS (*)
Fabulina fabula	NS (*)	L-NS (*)	L-NS (*)	M(*)	NS (*)	M(*)	M-H(*)	L(*)	L(*)	NS (*)	NS (*)	L(*)	M-H (*)	L-NS (*)	NS-L (***)	L-NS (*)	M(*)	NS (*)	NS (*)	NS (*)	NEv	L-M (*)	NS (*)
Glycera sp.	NS (*)	L-M (***)	L-M (*)	M(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (**)	NS (***)	NS (*)	NS (***)	NS (***)	NS (*)	NS (*)	NS (*)	NA	NEv	NS (***)	NS (*)
Hydrobia ulvae	L-NS (*)	L (***)	L(*)	M (*)	NS (***)	L(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	L(*)	L(*)	L(*)	NS (*)	NS (*)	NEv	NEv	M (*)	NS (*)
Lanice conchilega	NS (*)	NS-L (***)	NS-L (***)	M-H (*)	NS (*)	M-H (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	M (*)	M (*)	M-H (*)	NS (*)	NS (*)	NS (*)	NEv	L (***)	NS (*)
Nephtys hombergii	NS (*)	L(*)	L(***)	L(*)	NS(**)	NS (*)	L(*)	NS (*)	NS(**)	NS (*)	NS (*)	NS (*)	NS(**)	NS (*)	NS (***)	NS (***)	NS (*)	M(*)	NS (*)	NS(**)	NEv	M (***)	NS (*)
Nephtys cirrosa	NS (*)	L (***)	L (***)	L(*)	NS (***)	NS (*)	L(*)	NS (*)	L(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	M (*)	M (*)	NS (*)	NS (*)	NEv	NEv	NS (*)
Nematoda	NS (***)	NS (***)	NS (***)	L(*)	NS (*)	NS (***)	NS (***)	NS (***)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	L (***)	L (***)	NS (***)	NS (*)	L(*)	NS (***)	NEv	L (***)	NS (*)
Protodorvillea kefersteini	NS (*)	NS (*)	NS (*)	L-M(*)	L(*)	L(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (*)	M(*)	NS (*)	NS (*)	NS (*)	NEv	NS (*)	NS (*)
Phaxas pellucidus	NS (*)	M(*)	M(*)	H(*)	NS (***)	M(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L(*)	L-NS	NEv	NEv	M(*)	NS (*)	NS (*)	NS (*)	NEv	NEv	NS (*)

Species	Pressure Type																					
	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Extraction	Siltation	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments-sedimentation	Increased removal of primary production-phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
														(*)									
Pygospio elegans	L(*)	L (**)	M (***)	L-M (*)	L (***)	L-M (***)	L-M (*)	NS (**)	L-M (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	L (**)	L (**)	M (*)	NS (*)	NS (*)	NS (*)	NEv	NEv	NS (*)
Scoloplos armiger	NS (*)	L(*)	L-M (*)	H (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	M (***)	M (***)	M (*)	M (**)	NS (*)	NS (*)	NEv	NEv	NS (*)
Tubificoides spp.	NS (*)	NS (*)	L (**)	M (*)	NS (*)	L(*)	NS (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	NS (***)	NS (***)	NS (*)	NS (*)	NS (*)	NS (**)	NEv	NEv	NS (**)
Notomastus sp	NS (*)	L (***)	L (***)	L-M (*)	L(**)	L(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (**)	NS (*)	L(*)	L(*)	M(*)	NS (*)	NS (*)	NS (*)	NEv	NS (***)	NS (*)
Melinna palmata	NS (***)	NS (***)	NS (***)	M(*)	L (***)	M(*)	NS (*)	NS (*)	NS (*)	L(*)	NS (***)	NS (***)	NS (***)	NS (*)	NS (***)	NS (***)	L(*)	NS (*)	NS (*)	NS (***)	NEv	M (***)	NS (*)
Mysella bidentata	NS (*)	NS (*)	L-M (*)	M(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (**)	NS (**)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L-M (*)	NS (*)	NEv	NA	NS (*)
Prionospio spp.	NS (*)	NS (***)	NS (*)	L(*)	L (***)	L(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	NS (***)	NS (***)	L(*)	NS (*)	NS (*)	NS (***)	NEv	NS (***)	NS (*)
Scalibregma inflatum	NS (*)	L(*)	M(*)	M(*)	NS (***)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	NS (***)	NS (***)	NA	NS (*)	NS (*)	NS (*)	NS (*)	NEv	NS (*)
Spiophanes bombyx	L(*)	L (***)	L(***)	L(*)	NS (*)	L(*)	L(*)	L(*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	L (***)	L (***)	L(*)	NS (*)	NS (*)	NS (*)	NEv	L (***)	NS (*)
Thyasira flexuosa	L(*)	L (***)	L(*)	M-H (*)	NS (*)	M-H (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	M (***)	M (***)	M (*)	NS (*)	NS (*)	NS (***)	NEv	NS (***)	NS (*)

Table 10: Codes of sensitivity and confidence applying to species and pressure interactions presented in Tables 8 and 9.

Species x Pressure Interaction Codes for Tables 8 and 9	
NA	Not Assessed
Nev	No Evidence
NE	Not Exposed
NS	Not Sensitive
L	Low
M	Medium
H	High
VH	Very High
*****	Low confidence
******	Medium confidence
*******	High Confidence

Conclusion 1: It is concluded that, with three exceptions, the aquaculture activities individually and in-combination do not pose a risk of significant disturbance to the conservation features for habitats (and community types) in Kenmare River based primarily upon the spatial overlap and sensitivity analysis (Tables 11 and 12). The exceptions are the activity (**scallop culture**) occurring over **Maerl dominated community, *Pachycerianthus multiplicatus* community complex** and ***Zostera* dominated community**. In spite of the relatively benign nature of the culture proposed (placement of scallop seed on seafloor) it is still considered potentially disturbing to these extremely sensitive community types types, primarily by virtue of the dredging activity associated with the culture practice and the uncertain nature of the placement of large quantities of scallop seed upon seagrass beds and subsequent scuba diving activities.

Table 11: Interactions between the relevant aquaculture activities and the habitat feature Large shallow inlets and bays (1160) constituent communities with a broad conclusion on the nature of the interactions.

			1160 – Large shallow inlets and bays				
Culture Type	**Location**	**Method**	***Zostera*-dominated community**	***Maerl*-dominated community**	***P. multiplicatus* community**	**Muddy fine sands dominated by polychaetes and *Amphiura filiformis* community**	**Fine to medium sand with crustaceans and polychaetes community complex**
Mussel (*Mytilus edulis)* on ropes	Subtidal	Intensive	**N/A**	**N/A**	**N/A**	**Disturbing: No** **Justification:** The high density of stock will impact on seafloor due to organic enrichment (faeces and pseudofaeces) and stock drop off. However the species have high recoverability and are tolerant. This activity overlaps 0.12% of this community type (<15% threshold).	**Disturbing: No** **Justification:** The high density of stock will impact on seafloor due to organic enrichment (faeces and pseudofaeces) and stock drop off. However the species have high recoverability and are tolerant. This activity overlaps 2.67% of this community type (<15% threshold).
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	Intensive	**N/A**	**N/A**	**N/A**	**Disturbing: No** **Justification:** The high density of stock will impact on seafloor due to organic enrichment (faeces & pseudofaeces). However the species have high recoverability and are tolerant. The stock is confined in bags, is sourced from hatcheries and is diploid/triploid. This activity overlaps 0.03% of this community type (<15% threshold).	**Disturbing: No** **Justification:** The high density of stock will impact on seafloor due to organic enrichment (faeces & pseudofaeces). However the species have high recoverability and are tolerant. The stock is confined in bags, is sourced from hatcheries and is diploid/triploid. This activity overlaps 0.21% of this community type (<15% threshold).
Scallops (*Pecten maximus*) on seabed	Subtidal	Extensive	**Disturbing: Yes** **Justification:** Given the highly sensitive nature of this community type any activity is likely to have some impact either by increasing species (albeit native) biomass/density and the disturbance risks associated with harvest activities (dredging). This activity overlaps 2.52% of this community type (<15% threshold).	**Disturbing: Yes** **Justification:** Given the highly sensitive nature of the community type in question any activity is likely to have some impact either by increasing species (albeit native) biomass/density and the disturbance risks associated with harvest activities (dredging). This activity overlaps 27.89% of this community type (>15% threshold).	**Disturbing: Yes** **Justification:** Given the highly sensitive nature of the community type in question any activity is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 100% of this community type (>15% threshold).	**Disturbing: No** **Justification:** The activities associated with this culture type is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 0.92% of this community type (<15% threshold).	**Disturbing: No** **Justification:** The activities associated with this culture type is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 1.01% of this community type (<15% threshold).
Salmon (*Salmo salar)* in net pens	Subtidal	Intensive	**N/A**	**N/A**	**N/A**	**Disturbing: No** **Justification:** The community and species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.08% of this community type (<15% threshold).	**Disturbing: No** **Justification:** The community and species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.31% of this community type (<15% threshold).
Cumulative Impact Aquaculture			**Disturbing: Yes** **Justification:** This community type is not tolerant of any overlap of any activity. The cumulative pressure of likely impacting activities on this community type is 2.52%**.**	**Disturbing: Yes** **Justification:** This community type is not tolerant of any overlap of any activity. The cumulative pressure of likely impacting activities on this community type is significant at 27.89%**.**	**Disturbing: Yes** **Justification:** The cumulative pressure of likely impacting activities on this community type is significant at 100%**.**	**Disturbing: No** **Justification:** The cumulative pressure of likely impacting activities is 1.15% on this community type.	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 4.18% on this community type.

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Table 12 cont'd**: Interactions between the relevant aquaculture activities and the habitat feature Large shallow inlets and bays (1160) constituent communities with a broad conclusion on the nature of the interactions.**

			1160 – Large shallow inlets and bays			
Culture Type	**Location**	**Method**	**Coarse sediment dominated by polychaetes community complex**	**Intertidal reef community complex**	***Laminaria*-dominated community complex**	**Subtidal reef with echinoderms and faunal turf community complex**
Mussel (*Mytilus edulis)* on ropes	Subtidal	Intensive	**Disturbing: No** **Justification:** The high density of stock will impact on seafloor due to organic enrichment (faeces and pseudofaeces) and stock drop off. This activity overlaps 3.31% of this community type (<15% threshold).	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to stock drop off, smothering and siltation (faeces and pseudofaeces). This activity overlaps 5.05E-03% of this community type (<15% threshold).	**Disturbing: No** **Justification**: The community type is considered tolerant to pressures from activity. However the species are sensitive to stock drop off, smothering and siltation (faeces and pseudofaeces). This activity overlaps 1.35% of this community type (<15% threshold).	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to stock drop off, smothering and siltation (faeces and pseudofaeces). This activity overlaps 1.98% of this community type (<15% threshold).
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	Intensive	**N/A**	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.15% this community type (<15% threshold).	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.32% this community type (<15% threshold).	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.03% this community type (<15% threshold).
Scallops (*Pecten maximus*) on seabed	Subtidal	Extensive	**Disturbing: No** **Justification:** The activities associated with this culture type is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). However, this activity overlaps 0.47% of this community type (<15% threshold).	**Disturbing: No** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge. However this activity overlaps 0.20% of this community type (<15% threshold).	**Disturbing: No** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge. This activity overlaps 5.97% of this community type (<15% threshold).	**Disturbing: No** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge. This activity overlaps 0.19% of this community type (<15% threshold).
Salmon (*Salmo salar)* in net pens	Subtidal	Intensive	**Disturbing: No** **Justification:** The community type and species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.56% of this community type (<15% threshold).	**N/A**	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. The species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.30% of this community type (<15% threshold).	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. The species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.35% of this community type (<15% threshold).
Cumulative Impact Aquaculture			**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 4.33% on this community type.	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 0.36% on this community type.	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 7.74**%** on this community type.	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 2.54% on this community type.

Table 13: Interactions between the relevant aquaculture activities and the community type feature Reefs (1170) constituent communities with a broad conclusion on the nature of the interactions.

			1170 – Reef		
Culture Type	**Location**	**Method**	**Intertidal reef community complex**	***Laminaria*-dominated community complex**	**Subtidal reef with echinoderms and faunal turf community complex**
Mussel (*Mytilus edulis)* on ropes	*Subtidal*	*Intensive*	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to stock drop off, smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.01% of this community type (<15% threshold).	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to stock drop off, smothering and siltation (faeces and pseudofaeces). This activity overlaps 1.99% of this community type (<15% threshold).	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to stock drop off, smothering and siltation (faeces and pseudofaeces). This activity overlaps 2.08% of this community type (<15% threshold).
Oysters (*Crassostrea gigas*) in bags & trestles	*Intertidal*	*Intensive*	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.34% this community type (<15% threshold).	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.35% this community type type (<15% threshold).	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.03% this community type (<15% threshold).
Scallops (*Pecten maximus*) on seabed	*Subtidal*	*Extensive*	**Disturbing: No** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge This activity overlaps 0.15% of this community type (<15% threshold).	**Disturbing: No** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge This activity overlaps 5.46% of this community type (<15% threshold).	**Disturbing: No** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge This activity overlaps 0.19% of this community type (<15% threshold).
Salmon (*Salmo salar)* in net pens	*Subtidal*	*Intensive*	**N/A**	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.27% of this community type (<15% threshold).	**Disturbing: No** **Justification:** The community type is considered tolerant to pressures from activity. However the species are sensitive to smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.35% of this community type (<15% threshold).
Cumulative Impact Aquaculture			**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 0.50% on this community type.	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 8.07% on this community type.	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 2.65% on this community type.

8.4 Assessment of the effects of shellfish production on the Conservation Objectives for Harbour Seal in Kenmare River SAC.

Kenmare River SAC is designated for the Harbour Seal (*Phoca vitulina*). The distribution of the harbour seal and site use within the Kenmare River SAC are provided in Figure 3. The conservation objectives for this species are listed in Table 1 and can be found in detail in NPWS (2013a; 2013b). Recent harbour seal surveys (NPWS 2010, 2011, 2012) show the Kenmare River has maintained its importance on a regional and national scale in terms of Harbour Seal numbers, as indicated in earlier surveys (Cronin *et al*., 2004; Heardman *et al.,* 2006). While the conservation status of the species is therefore considered favourable at the site, the interactions between harbour seals and the features and aquaculture activities carried out in the SAC must be ascertained.

The interactions between aquaculture operations and aquatic mammal species are a function of:

1. The location and type of structures used in the culture operations - is there a risk of entanglement or physical harm to the animals from the structures or is access to locations restricted?

2. The schedule of operations on the site – is the frequency such that they can cause disturbance to the animals?

The proposed activities must be considered in light of the following attributes and measures for the Harbour Seal:

- Access to suitable habitat – number of artificial barriers
- Disturbance – frequency and level of impact
- Harbour Seal Sites:
    - Breeding sites
    - Moulting sites
    - Resting sites

Restriction to suitable habitats and levels of disturbance are important pressures that must be considered to ensure the maintenance of favourable conservation status of the harbour seal and implies that the seals must be able to move freely within the site and to access locations considered important to the maintenance of a healthy population. They are categorised according to various life history stages (important to the maintenance of the population) during the year. Specifically they are breeding, moulting and resting sites (Figure 3). It is important that the access to these sites is not restricted and that disturbance, when at these sites, is kept to a minimum. The structures used in culture of oysters (bags on trestles) may form a physical barrier to seals when both submerged and exposed on the shoreline such that the access to haul-out locations might be blocked. Activities at sites and during movement to and from culture sites may also result a disturbance events such that the seals may note an activity (head turn), move towards the water or actually flush into the water. While such disturbance events might have been documented, the impact of these disturbances at the population level has not been studied more broadly (National Research Council, 2009).

Intertidal oyster culture using bags and trestles has been conducted within the Kenmare River since the early 1990's. The current level of production, which remains quite small (<30 tonnes) is represented as licenced activities in Figure 4. It is considered that, given the favourable conservation status of Harbour Seals within the SAC represented by stable numbers since 2009 (NPWS 2012) that the current production levels (and activities associated with them) are conducive with favourable conservation status. However, some shellfish culture activities do physically overlap with designated seal sites identified in the SAC. In Coongar Harbour an oyster farm (licensed) and an application site for mussel culture is in very close proximity to a seal moulting site and in Ardgroom Harbour a mussel farm (licensed) overlaps a seal site (breeding). In Coonger Harbour, the seal site in question has multiple recordings of seals and therefore, would be considered an important location (Oliver O'Cadhla, NPWS - personal communication). The aquaculture site in question, has structures confined to the northern portion of the site and cannot expand beyond immediate areas based upon the topography of the site. This ensures that the activity will not occur in close proximity to the seal haul-out location. An expansion of intertidal aquaculture activity to areas in the immediate vicinity of the haul out locations would likely increase the risk of disturbance of the seals during the moulting period. The mussel application appears to be an expansion of existing operations it is therefore, likely the seals will be habituated or tolerant of disturbance from this activity.

In Ardgroom Harbour a single sighting was recorded at a mussel culture site during 2000 and 2001 (Lyons, 2003) – it is assumed, given the lack of natural structures at the site in question, that seal was hauled out on mussel rafts. The site in question has been licenced (and active) since 1992.

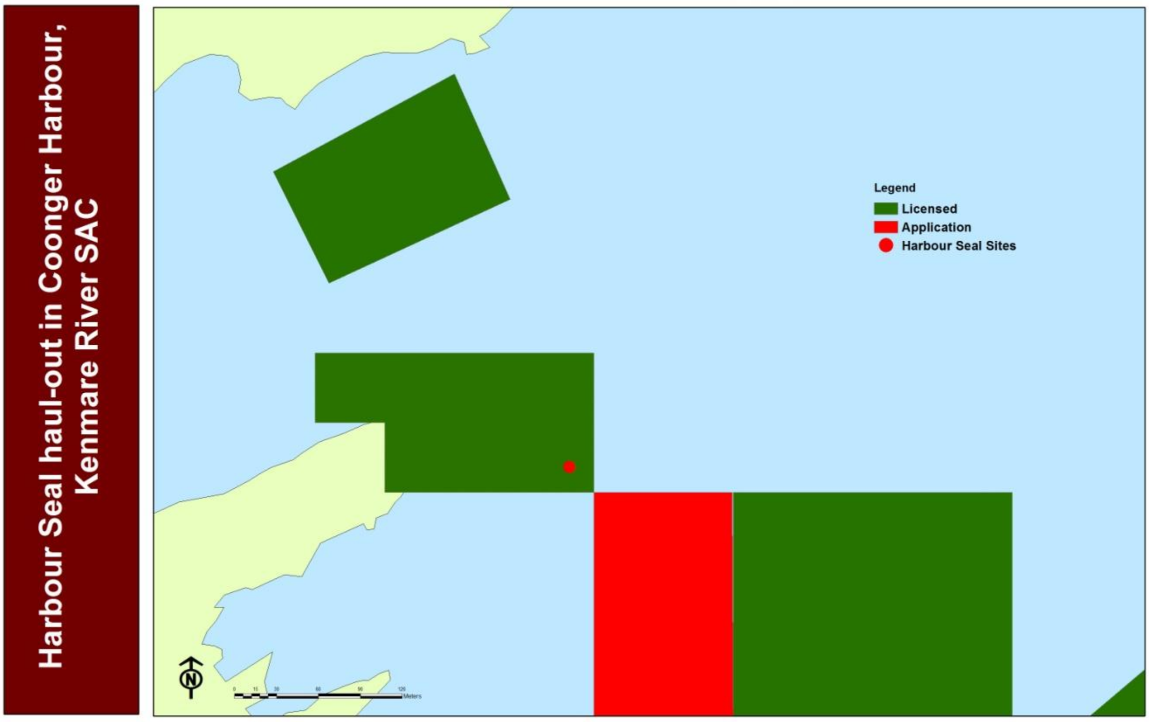
It should be noted that a finfish culture site within Killmakilloge Harbour is in close proximity to designated seal sites (breeding, moulting and haul out). As indicated previously, seal interactions with marine finfish cages have been identified (Aquaculture Stewardship Council, 2012). The risk to seals (as predators) result from their interaction with netting where if incorrectly configured (loose) the risk of drowning due to being entangled is increased. While a risk of entanglement in netting may present, it is not considered likely given that slack netting also presents a risk to culture organism in that it reduces the containment area. In terms of mitigation and in order to minimise risk to seals, the operators should employ a range of management actions including stock management (density control, regular removal of mortalities from cages), use of seal blinds and appropriate net tensioning. These practices are all considered suitable methods to minimise negative interactions between seals and finfish culture (Aquaculture Stewardship Council 2012). The use of Acoustic Deterrent Devices (ADDs) is not considered practical. Lethal actions to remove seals are only allowed under licence, the criteria which are determined by NPWS (Section 42 of the Wildlife Act, 1976 (as amended)).

Notwithstanding this, it would appear that the current level of activity at the sensitive times of the year (breeding and moulting, i.e. May to September) is sufficient to maintain stable seal counts at the site.

Conclusion 1: With one exception, the current levels of licenced shellfish and finfish culture and proposed applications are considered non-disturbing to harbour seal conservation features.

One exceptions to this conclusion is outlined above in Coonger Harbour (refer Figure 8). It is recommended that the boundaries for this intertidal oyster culture site be redrawn to exclude the area overlapping the seal haul-out locations which will mitigate further any disturbance risk to seals.

Figure 13: Aquaculture activity (oyster farm) overlapping Harbour Seal moulting site in Coongar Harbour.



Conclusion 2: Under the conditions described above, finfish culture is not considered disturbing to the Harbour Seal.

8.5 Assessment of the effects of aquaculture production on the Conservation Objectives for Otter and migrating Salmon in Kenmare River SAC.

<u>Otter</u>

As the aquaculture production activities within the SAC spatially overlap with otter (*Lutra lutra*) territory, these activities may have negative effects on the abundance and distribution of populations of the species.

The Kenmare River SAC is designated for the otter (*Lutra lutra*); the conservation objectives for such are listed in Table 1. The risk of negative interactions between aquaculture operations and aquatic mammal species is a function of:

1. The location and type of structures used in the culture operations- is there a risk of entanglement or physical harm to the animals from the structures?
2. The schedule of operations on the site – is the frequency such that they can cause disturbance to the animals?

Shellfish Culture: Shellfish culture operations are likely to be carried out in daylight hours. The interaction with the otter is likely to be minimal given that otter foraging is primarily crepuscular. It is unlikely that these culture types pose a risk to otter populations in the Kenmare River. Impacts can be discounted on the basis of the points below:

The proposed activities 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 aquaculture and fisheries activities.
- Shellfish production activities are unlikely to pose any risk to otter populations through entrapment or direct physical injury.
- The structures and activities associated this form of oyster culture structures are raised from the seabed (0.5m -1m) and are oriented in rows, thus allowing free movement through and within the site.
- Disturbance associated with vessel and foot traffic could potentially affect the distribution of otters at the site. However, the level of disturbance is likely to be very low given the likely encounter rates will be low dictated primarily by tidal state and in daylight hours.

Conclusion 3: The current levels of licenced shellfish culture and applications are considered non-disturbing to otter conservation features.

Finfish Culture: The structures (nets) involved in finfish culture may pose an entanglement hazard to otters. However if site conditions as outlined in the seal section above (Section 8.4) are maintained this risk will be greatly mitigated.

Conclusion 4: The current levels of licenced finfish culture and applications are considered non-disturbing to otter conservation features.

Salmon (*Salmo salar*)

The Blackwater River runs into the north shore of Kenmare River SAC and is designated as an SAC for salmon (Blackwater River (Kerry) SAC).

Significant declines in sea survival and reduced returns to the coast and rivers of Atlantic salmon in recent decades have been recorded in Ireland (Salmon Management Task Force Report (Anon., 1996); O'Maoileidigh *et al*., 2004; Jackson *et al*., 2011). The reasons for the reduced sea survival remain unclear and speculation has covered such issues as global warming effects (Friedland *et al*., 2000; Friedland *et al*., 2005), changes in locations or availability of prey species, loss of post-smolts as by-catch in pelagic fisheries, increased fishing pressure, riverine habitat changes and sea lice infestation (Finstad et al., 2007; SSCWSS 2013). However, despite many years of study, processes contributing to the high mortality of juvenile Atlantic salmon between ocean entry and the first winter at sea remain poorly understood (Jones, 2009).

The results of a long term study carried out in the Burrishoole system in Co. Mayo (Jackson *et al*., 2011) show a strong and significant trend in increasing marine mortality of Atlantic salmon originating from the Burrishoole system. They would also point to infestation of outwardly migrating salmon smolts with the salmon louse (*L. salmonis*) as being a minor and irregular component of marine mortality in the s**t**ocks studied and not being implicated in the observed decline in overall survival rate. The results of this study have been corroborated by studies carried out by the Marine Institute as part of a detailed investigation into the potential impacts of sea lice on a number of other river systems, including the Newport River (Jackson *et al*., 2013a).

The Irish State has developed a comprehensive control and management strategy for sea lice infestations on farmed salmonids. This systems is underpinned by research dating back to the early 1990s and was the basis for the introduction of the original lice monitoring programme (Jackson and Minchen, 1993). Subsequent research (Jackson *et al.,* 2000; Jackson *et al.,* 2002) informed the development of a set of management protocols published by the Department of Marine in 2000 (Anon., 2000). The full implementation of these protocols resulted in improved sea lice control on farmed salmon (O'Donohoe *et al*., 2013). There has been a policy of utilising research to ensure that the most up to date and effective treatment and management regimes are in place to control sea lice on Irish farms and this has included research into techniques to assess the most effective treatment regimes (Sevatdal *et al*., 2005) and the sources of sea lice infestation in the marine environment (Jackson *et al.*, 1997; Copley *et al*., 2005; Copley *et al.,* 2007).

The monitoring and control system in place is comprehensive, transparent and independent. The Irish management and control system is widely regarded as best international practice because it has low treatment trigger levels, is based on independent inspection regimes, has a robust follow-up on problem areas and Ireland is the only country in the world to publish the results of the independent state run inspection programme in full each year (O'Donohoe *et al.,* 2013). Following the introduction of the "S*trategy for improved pest control on Irish salmon farms*" in 2008 by the Department of Agriculture Fisheries and Food there were significant improvements in sea lice management in Ireland (Jackson, 2011).

The control strategy is aimed at implementing a more strategic approach to lice control at a bay level and targeting efforts on the spring period where there is a potential for impacts on wild smolts embarking on their outward migration. The effectiveness of the system is witnessed by trends in sea lice infestation on farmed fish in the peak period for wild salmon smolt migration having shown a strong downward trend since the introduction of the new management strategy (Jackson *et al.,* 2013). As indicated previously, in relation to **disease interactions**, any risks of disease transfer between cultured finfish and wild fish are mitigated by the management systems currently in place. In summary, Council Directive 2006/88/EC on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals form the legislative basis that governs the monitoring and management of disease outbreaks in mariculture operations in Ireland. For diseases not listed in this Directive, a Code of Practice and Fish Health Handbook has been developed jointly by the State and industry with the primary objectives of disease prevention and control.

Active veterinary surveillance and intervention has assisted in reducing the prevalence and spread of many pathogens. In addition, the principles outlined in the Fish Health Handbook mentioned above such as improved biosecurity practices on farms, fallowing sites to break transmission cycles, veterinary inspection of fish prior to transfer, single year class stocking, coordinating treatments and harvesting within embayments etc have mitigated the transmission of pathogenic organisms.

Notwithstanding the issues highlighted above, it is concluded that aquaculture production in the Kenmare River SAC does 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)**

8.6 Assessment of the effects of shellfish production on the Conservation Objectives for Maerl in the Kenmare River SAC.

Maerl dominated community occurs in certain areas (Ardgroom and Killmakilloge Harbours) which are outside of the Qualifying Interests for which the Kenmare River SAC was designated but are still within the SAC boundary. Maerl, the characterising species of this community, is listed as an Annex V species and as it is within the SAC boundary it must be afforded protection.

Aquaculture activity (suspended mussel culture) within Ardgroom harbour spatially overlaps (1.84%) with the Maerl dominated community and may have negative effects on the distribution and quality of this community type (Figure 10). The potential effects of this aquaculture type which are listed in Table 5, include current alteration, increased deposition and shading. Table 8 lists the sensitivities of community types to various pressure types according to ABPMer (2013b). According to ABPMer (2013b) Maerl habitats are restricted to shallow coastal waters by requirements for light penetration hence this species has a high sensitivity to increased turbidity, is sensitive to decrease in water flow speed and organic enrichment of sediments. Based on the findings of the later report the proposed activity (suspended mussel culture) will therefore have an adverse effect on the species for the following reasons:

Maerl is very highly sensitive to the following which may result as a consequence of suspended culture operations:

- Siltation (addition of fine sediments, pseudofaeces).
- Smothering (addition of materials biological or non-biological to the surface).
- Change in water flow due to permanent/semi permanent structures placed in the water column).
- Change in turbidity/suspended sediment/Increased suspended sediment turbidity.

Conclusion 5: Suspended mussel culture in Ardgroom Harbour is disturbing to Maerl dominated community.

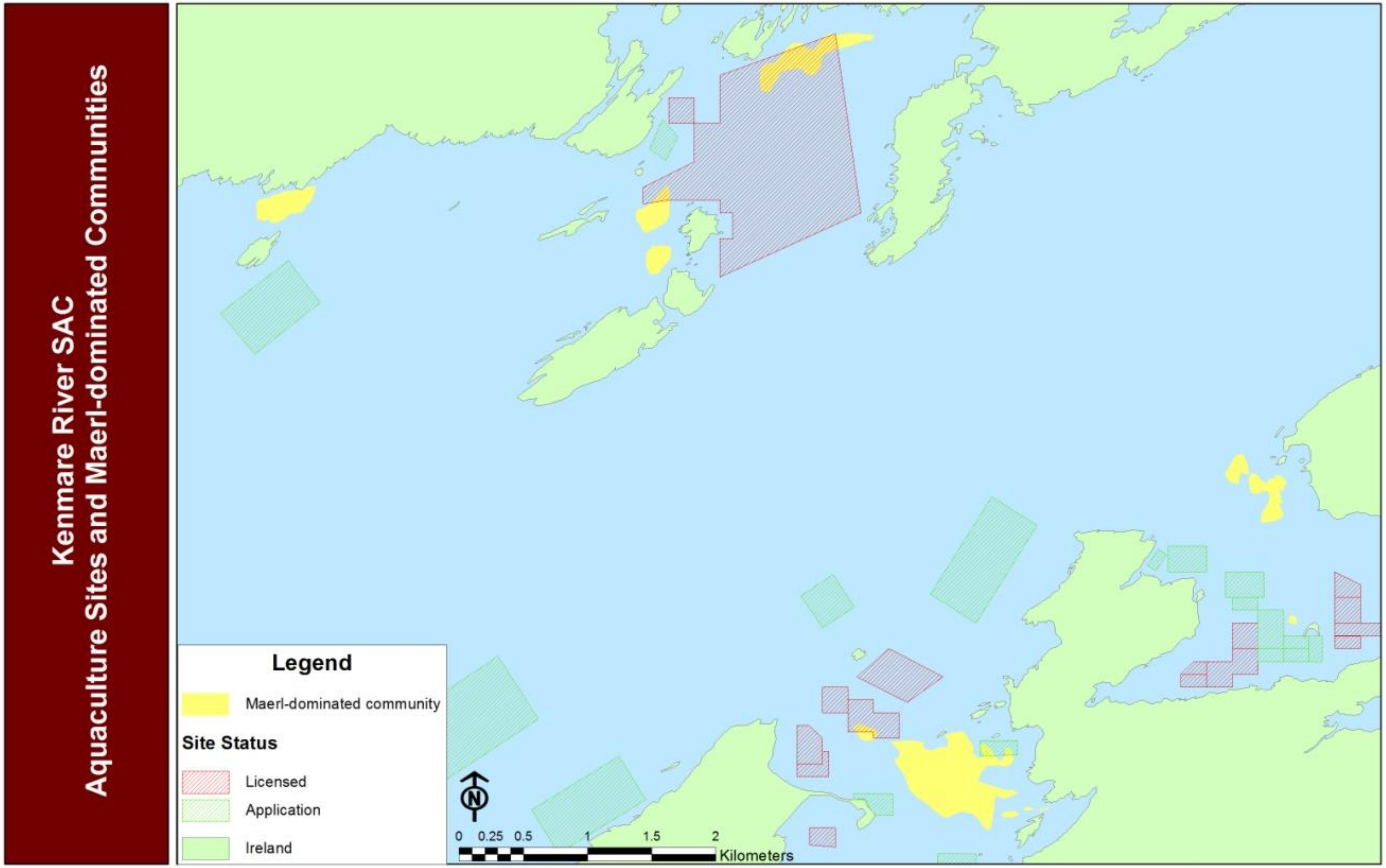


Figure 14. Aquaculture activities overlapping Mearl habitat in Kenmare River SAC.

9. Assessment of Fisheries Activities

9.1. Fisheries:

The risk assessment framework for fisheries follows, where feasible, EC guidance (2012) and includes elements of risk assessment from Fletcher (2002, 2005). The qualitative and semi-quantitative framework is described in Marine Institute (2013) and criteria for risk categorization is shown in Tables 14 and 15 below.

The framework uses categorical conditional probability matrices of likelihood and consequence to assess the risk of an activity to a conservation feature. Categorical likelihood and consequence scores for each such 'incident' (fishery-designated feature interactions) are provided by expert judgment and a base literature resource which has been pre-compiled for each habitat type defined in the COs.

Separate conditional probability matrices for habitats and designated species are used to assess risk. In the case of habitats the consequence criteria largely follow the definitions and methodologies used for AA of projects and plans. In the case of species the consequence categories relate to the degree to which populations and their supporting habitats may be negatively affected by the given activity.

9.1.2. Sensitivity of characterizing species and marine communities to physical disturbance by fishing gears

- The approach and rationale to assessment of the sensitivity of species and habitats to fishing activities and the information used in this assessment is similar to that outlined for aquaculture
- NPWS (2012b) provide lists of species characteristic of the habitats that are defined in the Conservation Objectives. The sensitivity of these species to various types of pressures varies and the species list varies across habitats.
- Pressures due to fishing are mainly physical in nature i.e. the physical contact between the fishing gear and the habitat and fauna in the habitat causes an effect.
- Physical abrasive/disturbing pressures due to fishing activity of each metier maybe classified broadly as causing disturbance at the seabed surface and/or at the sub-surface.
- Fishing pressures on a given habitat is related to vulnerability (spatial overlap or exposure of the habitat to the gear), to gear configuration and action, frequency of fishing and the intensity of the activity. In the case of mobile gears intensity of activity is less relevant than frequency as the first pass of the gear across a given habitat is expected to have the dominant effect (Hiddink *et al.*. 2007).
- Sensitivity of a species or habitat to a given pressure is the product of the resilience of the species to the particular pressure and the recovery capacity (rate at which the species can recover if it has been affected by the pressure) of the species. Morphology, life history and biological traits are important determinants of sensitivity of species to pressures from fishing and aquaculture.

- The separate components of sensitivity (resilience, recoverability) are relevant in relation to the persistence of the pressure
    - For persistent pressures, i.e. fishing activities that occur frequently and throughout the year, recovery capacity may be of little relevance except for species/habitats that may have extremely rapid (days/weeks) recovery capacity or whose populations can reproduce and recruit in balance with population reduction caused by fishing. In all but these cases, and if resilience is moderate or low, then the species may be negatively affected and will exist in a modified state. Such interactions between fisheries and species/habitats represent persistent disturbance. They become significantly disturbing if more than 15% of the community is thus exposed (NPWS 2012b).
    - In the case of episodic pressures i.e. fishing activities that are seasonal or discrete in time both the resilience and recovery components of sensitivity are relevant. If resilience is low but recovery is high, relative to the frequency of application of the pressure, than the species/community will be in favourable conservation status for a given proportion of time
- The sensitivities of some species, which are characteristic (as listed in the COs) of benthic communities, to physical pressures similar to that caused by fishing gears, are described above.
- In cases where the sensitivity of a characterising species (NPWS 2011b) has not been reported this risk assessment adopts the following guidelines
    - Resilience of certain taxonomic groups such as emergent sessile epifauna to physical pressures due to all fishing gears is expected to be generally low or moderate because of their form and structure (Roberts *et al.* 2010).
    - Resilience of benthic infauna (eg bivalves, polychaetes) to surface pressures, caused by pot fisheries for instance, is expected to be generally high as such fisheries do not cause sub-surface disturbance
    - Resilience of benthic infauna to sub-surface pressures, caused by toothed dredges and to a lesser extent bottom otter trawls using doors, may be high in the case of species with smaller body sizes but lower in large bodied species which have fragile shells or structures. Body size (Bergman and van Santbrink 2000) and fragility are regarded as indicative of resilience to physical abrasion caused by fishing gears
    - Recovery of species depends on biological traits (Tillin *et al.* 2006) such as reproductive capacity, recruitment rates and generation times. Species with high reproductive capacity, short generation times, high mobility or dispersal capacity may maintain their populations even when faced with persistent pressures but such environments may become dominated by these (r-selected) species. Slow recovery is correlated with slow growth rates, low fecundity, low and/or irregular recruitment, limited dispersal capacity and long generation times

Table 14. Risk categorization for fisheries and designated habitat interactions (see: Marine Institute 2013). Colours indicate risk category. Disturbance is defined as that which leads to a change in characterising species. Such disturbance may be temporary or persistent depending on the frequency of impact and the sensitivity of the receiving environment. Colours indicate the probable need for mitigation of effects from green (no mitigation needed), to yellow (mitigation unlikely to be needed but review on a case by case basis), orange (mitigation probably needed) and red (mitigation required)

Habitats			**Consequence criteria**					
			Activity is not present or has no contact with habitat	Activity occurs and is in contact with habitat	Up to 15% overlap of fishery and habitat seasonally.	Over 15% overlap of fishery and habitat seasonally.	Over 15% of habitat disturbed persistently leading to cumulative impacts	Impact is effectively permanent due to severe habitat alteration.
			No change due to fishing activity can occur	Individual effects on characterising species but this is undetectable relative to background natural variability	Seasonal change in characterising species and community structure and function	Seasonal change in characterising species and structure and function	Persistent change in characterising species, structure and function	Biodiversity reduction associated with impact on key structural species
						Frequency of disturbance < recovery time. Non-cumulative	Frequency of disturbance> recovery time. Cumulative	No recovery or effectively no recovery
Likelihood	**%**	Level	**0**	**1**	**2**	**3**	**4**	**5**
Highly likely	>95	**5**	0	5	10	15	20	25
Probable	50-95	**4**	0	4	8	12	16	20
Possible	20-50	**3**	0	3	6	9	12	15
Unlikely	1-20	**2**	0	2	4	6	8	10
Remote	1	**1**	0	1	2	3	4	5

Table 15. Risk categorization for fisheries and designated species interactions (Marine Institute 2013)

Species			**Consequence criteria**					
			Activity is not present and individuals or population cannot be affected	Activity present. Individuals in the population affected but effect not detectable against background natural variability	Direct or indirect mortality or sub-lethal effects caused to individuals by the activity but population remains self-sustaining	In site population depleted by the activity but regularly sub-vented by immigration. No significant pressure on the population from activities outside the site	Population depleted by the activity both in the site and outside of the site. No immigration or reduced immigration	Population depleted and supporting habitat significantly depleted and unable to continue to support the population
Likelihood	**%**	Level	**0**	**1**	**2**	**3**	**4**	**5**
Highly likely	>95	**5**	**0**	**5**	**10**	**15**	**20**	**25**
Probable	50-95	**4**	**0**	**4**	**8**	**12**	**16**	**20**
Possible	20-50	**3**	**0**	**3**	**6**	**9**	**12**	**15**
Unlikely	1-20	**2**	**0**	**2**	**4**	**6**	**8**	**10**
Remote	1	**1**	**0**	**1**	**2**	**3**	**4**	**5**

9.1.3. Spatial overlap of fisheries and qualifying interests

Percentage spatial overlap of fisheries on marine community types within each Qualifying Interest is shown below in Table 16. The footprint of each fishery is the area of the polygon within which the fishery takes place and is an exaggeration of the actual area over which gear is deployed, especially in the case of static gears (Traps, Gill nets, Tangle nets, Trammel Nets). In some cases (Hooks and Lines) there is overlap with the marine community type but no pressure or footprint as the gear is not in contact with the seabed.

Table 16. Spatial overlap of fisheries and marine community types in Kenmare River SAC. There are no fisheries on intertidal mobile sands or on shingle communities. Spatial overlap of demersal and pelagic trawls, as shown by Vessel Monitoring System data, is not quantified and is presented as absent or present. Overlap of multiple fisheries occur on community types making the calculation of cumulative spatial overlap impractical.

QI/SCI	Marine Community Type	Fishing current	Trap - lobster	Trap - crab	Trap - shrimp	Trap - Nephrops	Dredge - scallop	Gill net	Tangle net crayfish	Trammel netting bait	Otter trawl - demersal	Mid-water trawl	Hooks and Lines	Hand gathering winkles
Large shallow inlets and bays [1160]	Intertidal mobile sand community complex	Yes	0	0	0	0	0	0	0	0	0	0	0	0
Large shallow inlets and bays [1160]	Zostera dominated community	Yes	0	0	50	0	0	0	0	0	0	0	0	
Large shallow inlets and bays [1160]	Co-occurrence Zostera and maerl community complex	Yes	100	100	100	0	0	0		100	0	0	0	
Large shallow inlets and bays [1160]	Maërl-dominated community	Yes	95	95	98	0	0	0	0	95	0	0	0	
Large shallow inlets and bays [1160]	Pachycerianthus multiplicatus community	Yes	0	0	100	0	0	0	0	0	0	0	0	
Large shallow inlets and bays [1160]	Muddy fine sands dominated by polychaetes and Amphiura filiformis community complex	Yes	20	20	17	1	1	1	14	20	1	1	33	
Large shallow inlets and bays [1160]	Fine to medium sand with crustaceans and polychaetes community complex	Yes	55	55	28	2	9	1	0	55	1	1	0	
Large shallow inlets and bays [1160]	Coarse sediment dominated by polychaetes community complex	Yes	36	36	7	0	6	1	18	36	1	1	2	
Large shallow inlets and bays [1160]	Shingle	Yes	0	0	0	0	0	0	0	0	0	0	0	0
Large shallow inlets and bays [1160]	Intertidal reef community complex	Yes	0	0	0	0	0	0	0	0	0	0	0	1
Large shallow inlets and bays [1160]	Laminaria-dominated community	Yes	34	34	30	1	0	1	3	34	1	1	0	
Large shallow inlets and bays [1160]	Subtidal reef with echinoderms and faunal turf community complex	Yes	30	30	11	0	6	1	12	30	1	1	1	
Reefs [1170]	Intertidal reef community complex	Yes	0	0	0	0	0	0	0	0	0	0	0	1
Reefs [1170]	Laminaria-dominated community	Yes	38	38	35	1	0	1	2	38	1	1	0	

Reefs [1170]	Subtidal reef with echinoderms and faunal turf community complex	Yes	37	37	12	0	0	1	12	37	1	1	1	

9.1.3. Risk assessment of the impact of fishing gears on marine benthic communities

- The list of fishing activities (métiers) operating in Kenmare Bay is described above
- The sensitivity of marine communities, which are the subject of the COs to physical disturbance that may be caused by fishing gears is in Table 8.
- The risk assessment framework outlined in Table 14 and Table 15 for habitats and species respectively provides a rationale for assessing and scoring risk posed by fishing activities to the conservation objectives. More detailed explanation is provided in Marine Institute (2013).
- One of the risk assessment criteria for habitats is the % overlap of the activity and each habitat. The overlap of fisheries and marine community types within those habitats is in presented in Table 16.
- Risk scores for effects of individual fisheries on marine community types and species are in Table 17.

9.2 Fisheries Risk profile

9.2.1. Marine Community types

9.2.1.1. Trap fisheries for lobster, crab, shrimp and *Nephrops*

- Trap fisheries may pose a risk to sensitive habitats such as Zostera and Maerl due to abrasion and disturbance caused by pots, ropes and anchors. The effect will depend on the intensity and frequency of the activity and the gear configuration in terms of pot spacing, number of anchors used, type of rope etc. Trap fisheries for *Nephrops* will not occur on this ground. Shrimp fisheries may occur on the *Pachycerianthus* community and there is a low risk of impact to this species.
- Trap fisheries may pose some risk to kelp reef communities and to sub-tidal faunal turf reefs depending on the intensity of the potting activity. This risk is likely to be low however against background variability in these communities.
- Pot fisheries pose no risk to sedimentary habitats

9.2.1.1. Dredge fisheries for scallop

- Dredge fisheries for scallop occurs on sub-tidal reef community and may have an impact on this community. There is some uncertainty as to the location of this fishery and its relation to aquaculture applications for bottom culture of scallop
- Dredging for surf clams may occur in sedimentary habitats in Kenmare River (spatial analysis not shown). They are not currently fished, no surveys of their distribution have been undertaken and the site is not a classified production area for this species. The risk posed to sedimentary habitats from a surf clam fishery is low.

9.2.1.2. Set net fisheries

- Gill net, tangle nets and trammel nets are used to capture mixed fish, crayfish and bait respectively
- The extent of trammel netting is unknown and here it is assumed to have the same footprint of the lobster fishery as trammel nets are used primarily to catch bait species for lobster pots. If they are used the associated anchors and footropes may impact Zostera and Maerl beds and may have lesser impacts on kelp reefs which are less sensitive to disturbance than Zoster or Maerl.
- Tangle nets and gill nets are likely to be used in deeper waters away from kelp reefs or Zostera and Maerl beds.

9.2.1.3. Bottom trawl fisheries

- Bottom trawling in Kenmare Bay occurs mainly in the outer part of the site in the muddy fine sand community complex. Fishing in the eastern part of the site by vessels >15m is close to zero. It also occurs on medium fine sand. Annual VMS effort for vessels >15m, between 2006-2012 in the site was approximately 350 hrs. The distribution of VMS points indicates that over 15% of the muddy fine sand community is fished. Fishing occurs in all months of the year
- Muddy fine sand communities, particularly suspension feeders and crustaceans, are sensitive to fishing pressure from trawls but this depends on intensity of the fishing pressure. The community is not sensitive to low levels of trawling (a single pass for instance). Recovery time is prolonged compared to coarser substrates due to the fact that such habitats are mediated by a combination of biological, chemical and physical processes compared to coarse substrates which are dominated by physical processes (ABPMer 2013. Muddy sands. Appendix F,). Recovery times from impacts may take years.
- The intensity of trawling by vessels over 15m in length in outer Kenmare River could be classed as medium (using scales provided by the Beaumaris approach to sensitivity assessment, ABPMer 2012. Muddy sands. Appendix F, p. 71) and some of the habitat probably experiences more than a single pass of the gear per annum. Activity by vessels under 15m is unquantified. The community therefore may be impacted. Impact would increase if fishing effort escalated.
- In Kenmare the anthozoan *Virgularia mirabilis* occurs in the muddy fine sand community but is unlikely to be affected by trawling as it occurs in the inner Bay.

9.2.1.3. Mid-water trawl fisheries and hook and line fisheries

– These fisheries are not expected to impact marine habitats in Kenmare Bay

9.2.1.3. Hand gathering of periwinkles

– Hand gathering of periwinkles occurs on intertidal reef communities. There is a low risk of impact in such communities due to trampling pressure. However, although the intensity of the activity is unknown it is unlikely to be such that significant effects would occur.

Table 17. Risk assessment for fisheries-marine community type interactions in Kenmare River SAC.

QI/SCI	Marine Community Type	Trap - lobster	Trap - crab	Trap - shrimp	Trap - Nephrops	Dredge - scallop	Gill net	Tangle net crayfish	Trammel netting bait	Otter trawl - demersal	Mid-water trawl	Hand gathering winkles	Hooks and Lines
Large shallow inlets and bays [1160]	Co-occurrence Zostera and maerl community complex	16	16	16					16				
Large shallow inlets and bays [1160]	Zostera dominated community			12									
Large shallow inlets and bays [1160]	Maërl-dominated community	16	16	16					16				
Large shallow inlets and bays [1160]	Pachycerianthus multiplicatus community			9									
Large shallow inlets and bays [1160]	Muddy fine sands dominated by polychaetes and Amphiura filiformis community complex	4	4	4	4		4	4	4	12	4		2
Large shallow inlets and bays [1160]	Fine to medium sand with crustaceans and polychaetes community complex	4	4	4	4		4		4	12	4		
Large shallow inlets and bays [1160]	Coarse sediment dominated by polychaetes community complex	4	4	4			4	4	4	12	4		2
Large shallow inlets and bays [1160]	Intertidal reef community complex											6	
Large shallow inlets and bays [1160]	Laminaria-dominated community	9	9	9	9		4	4	9	4	4		
Large shallow inlets and bays [1160]	Subtidal reef with echinoderms and faunal turf community complex	9	9	9		8	4	4	9	4	4		2
Reefs [1170]	Laminaria-dominated community	9	9	9	9		4	4	9	4	4		
Reefs [1170]	Subtidal reef with echinoderms and faunal turf community complex	9	9	9			4	4	9	4	4		2
Large shallow inlets and bays [1160]	Intertidal reef community complex											6	

9.2.2. Species

9.2.2.1. Harbour Seal

- Harbour seals haul out in sheltered waters, typically on sandbanks and in estuaries, but also in rocky areas and may swim upstream into freshwater. They undertake smaller scale foraging movements (30km from the haul out site) and migrations than grey seal. Pups remain in their natal area after weaning (Wilson *et al*. 2003, Cronin *et al*. 2008). Space use maps for Harbour seals tagged in Kenmare River shows very limited movement outside of Kenmare River SAC (Figure 14).

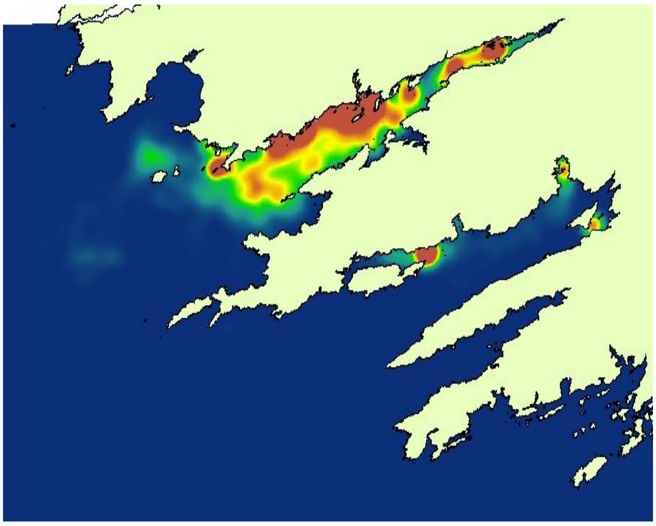


Figure 15. Space use maps for tagged Harbour seals in Kenmare river (source: Cronin *et al*. 2008)

- Number of Harbour seals in Kenmare River declined slightly from 413 to 390 between Census counts in 2003 and 2011
- Tangle nets are used at the mouth of Kenmare River within the foraging range of seals at the site.
- Gill net use is reported by vessels over 15m in Kenmare River within the foraging range of seals from Kenmare River
- Pelagic trawling for sprat (with herring by-catch) occurs in Kenmare River and east to the upper reaches of the Bay.
- Demersal trawling occurs in outer Kenmare River but within the Kenmare River SAC.
- Potting for shrimp occurs in inner Kenmare river while lobster and crab potting, with the possible use of trammel nets for bait, occurs along the south and north shores of the outer Bay.
- By-catch risk is highest for gill net fishing and pelagic fishing in inner Kenmare River. There may be a by-catch in trammel nets. The pelagic fishery for sprat and pot fisheries may cause disturbance at haul out locations which are mainly in the inner Bay on north and south shores.

Cumulative risk posed by fisheries may result in sub-lethal and lethal effects on individual seals but the risk to the population may be relatively low. However, total annual by-catch of Harbour Seal in Kenmare River is unknown.

- Risk of by catch, prey depletion and disturbance does not exceed a value of 6 and is considered to be low.

9.2.2.1. Otter

- Otter (*Lutra lutra*) is listed in Annex II of the Habitats Directive. Otter is common throughout freshwater systems in Ireland and also occurs in coastal marine habitats.
- There is a low risk of capture of otters in lobster pots and trammel nets set in shallow water (<5m). Such mortality has been documented elsewhere.
- Because of the intensity of pot fishing, unknown levels of associated use of trammel nets and documented accounts of mortality of otter in parlour creels in particular there is some likelihood of capture of individual otters. As creels and trammels are unlikely to be deployed within the preferred dive range of otters in the Irish lobster fishery the likelihood of capture is thought to be unlikely

10. In-combination effects of aquaculture, fisheries and other activities

Given the uncertainty in relation to scallop fishing the assessment of in-combination effects of this activity and scallop culture (which is in-effect a type of fishery activity) are difficult to estimate. It is likely that the 'wild' fishery activities will not occur in the aquaculture plots if they are actively maintained.

Those fishery activities that overlap with sensitive community types or represent a risk identified in Table 17 should be subject to mitigation measures the extent of which are beyond the scope of this report. Other fishery activities have little or no overlap with aquaculture activities and are subject to separate management actions.

Other activities leading to potential impacts on conservation features relate to harvest of seaweed on intertidal reef communities. There is little known concerning the level of harvest from these intertidal reef communities. The impact is likely two-fold, direct impact upon the reefs by removal of a constituent species and impact upon intertidal sediments as a consequence of travel across the shore to the harvest sites. The likely overlap between these activities and intertidal shellfish culture is considered small as the (reef) habitat is not considered suitable for shellfish culture and low levels of this culture method overlaps this habitat. Seaweed harvesting requires a foreshore licence administered by the Department of Environment, Community and Local Government. The level of transport across the intertidal area is unknown, but it is presumed that the routes are well defined.

Seal watching cruises are conducted in Kenmare. The extent of these activities are confined to the inner portions of Kenmare River SAC and do not overlap with the aquaculture operations. It is assumed that these activities are subject to a separate AA process?

There are a number of activities which are terrestrial in origin that might result in impacts on the conservation features of the Kenmare River SAC. Primary among these are point source discharges from municipal and industrial units (Shellfish Pollution Reduction Programme, DECLG). There are five urban waste water treatment plants in the general vicinity of the SAC. These are found in Ardgroom, Kenmare, Sneem, Kilgarvan, Eyeries. The pressure derived from these facilities is a discharge that may impact upon levels of dissolved nutrients, suspended solids and some elemental components e.g. aluminium in the case of water treatment facilities. It should be noted that the pressures resulting from fisheries and aquaculture activities are primarily morphological in nature. It was, therefore, concluded that given the pressure resulting from say, a point discharge location (e.g. urban waste-water treatment plant or combined sewer overflow) would likely impact on physico-chemical parameters in the water column, any in-combination effects with aquaculture or fisheries activities are considered to be minimal or negligible.

No other activities resulting in morphological and/or disturbance pressures were identified or could be quantified.

11. SAC Aquaculture Appropriate Assessment Concluding Statement and Recommendations

In the Kenmare River SAC there are a range of aquaculture activities currently being carried out or proposed. Based upon this and the information provided in the aquaculture profiling (Section 5), the likely interaction between this aquaculture and conservation features (habitats and species) of the site were considered.

An initial screening exercise resulted in a number of habitat features and species being excluded from further consideration by virtue of the fact that no spatial overlap of the culture activities was expected to occur. The habitats and species excluded from further consideration were1014 Marsh Snail *Vertigo angustior*, 1220 Perennial vegetation of stony banks, 1230 Vegetated sea cliffs of the Atlantic and Baltic coasts, 1330 Atlantic salt meadows (Glauco-Puccinellietalia maritimae), 1410 Mediterranean salt meadows (*Juncetalia maritimi*), 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes"), 2130 Fixed coastal dunes with herbaceous vegetation (grey dunes), 4030 European dry heaths and 6130 Calaminarian grasslands of the *Violetalia calaminariae* and Submerged or partially submerged sea caves (8330).

9.1 Habitats

A full assessment was carried out on the likely interactions between aquaculture operations (as proposed) and the Annex 1 habitats 1160 (Large Shallow Inlets and Bay), and 1170 (Reefs). The likely effects of the aquaculture activities (Species, structures) were considered in light of the sensitivity of the constituent community types and species of the Annex 1 habitats.

Conclusion and Recommendation - Aquaculture Activities: Of the 11 community types listed under the remaining habitat features (1160 and 1170) two (Intertidal mobile sand community complex and Shingle) were also excluded from further analysis as they had no overlap with aquaculture activities.

Based upon the scale of spatial overlap and the relatively high tolerance levels of the habitats and species therein, the general conclusions relating to the interaction between current and proposed aquaculture activities with habitats is that consideration can be given to licencing (existing and applications) in the Annex 1 habitats – 1160 (Large Shallow Inlets and Bays and 1170 (Reefs) with the exception of activities overlapping the following community types:

1. **Zostera-dominated community**- This habitat is not tolerant of any overlap of any activity. The cumulative pressure of likely impacting activities on this habitat is 2.52%**.**
2. **Maerl-dominated community -** This habitat is not tolerant of any overlap of any activity. The cumulative pressure of likely impacting activities on this habitat is significant at 27.89%**.**
3. ***Pachycerianthus multiplicatus* community -** The cumulative pressure of likely impacting activities on this habitat is significant at 100%**.**

It is important to note that licenced areas impacted by aquaculture that might be redrawn to exclude any overlap with sensitive habitats should include a sufficient buffer zone to allow for mapping resolution and/or visual enforcement of exclusion. Furthermore, there is still the risk that wild fishery interests might still dredge for scallop in these areas; therefore, it is recommended that some understanding should be arrived at between aquaculture management and fishery management interests in relation to these areas.

Also, it might be worth discussing whether the scallop culture activities as described (i.e., with harvest by dredging) can be considered an 'aquaculture' activity as distinct from a wild fishery, given that seeding is questionable and that 'culture' areas are very large.

Finally, the likely interaction between the proposed aquaculture activities and the Annex V species Maerl was assessed in areas where the maerl habitat did not fall under the Qualifying Interests but was still within the SAC boundary. It is **also concluded** that the aquaculture activity (suspended mussel culture) in Ardgroom Harbour is disturbing to this community type.

9.2 Species

The likely interactions between the proposed aquaculture activities and the Annex II Species Harbour Seal (*Phoca vitulina*) and Otter (*Lutra lutra*) were also assessed. The objectives for these species in the SAC focus upon maintaining the good conservation status of the population and consider certain uses of intertidal habitats as important indicators of status. The aspect of the culture activities that could potentially disturb the Harbour seal status relates to movement of people and vehicles within the sites as well as accessing the sites over intertidal areas and via water.

Conclusion and Recommendation: It is acknowledged in this assessment that the favourable conservation status of the Harbour seal (*Phoca vitulina*) has been achieved given current levels of aquaculture production within the SAC. On this basis, the current levels of licenced aquaculture (existing and renewals) are considered non-disturbing to harbour seal conservation features. However, there is one exception:

- Aquaculture activity (oyster farm) overlaps a Harbour Seal moulting site in Coongar Harbour and is recommended that the site boundaries be redrawn to exclude the overlap of harbour seal haul-out site.

In relation to new applications, given the lack of spatial overlap or the fact that applications which are adjacent to haul-out sites represent expansion of existing activities (and tolerance or acclimatisation has occurred) it is considered that the aquaculture activities proposed (applications) do not pose a threat to the harbour seal in the Kenmare River SAC.

The current levels of licenced aquaculture operations and applications are considered non-disturbing to Otter (*Lutra lutra)* conservation features.

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Report supporting Appropriate Assessment of Aquaculture and Fisheries Risk Assessment in Kenmare River SAC

(Site Code: 02158)

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1. Preface

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

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

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

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

2. Executive summary

2.1 The SAC

Kenmare River is designated as a Special Area of Conservation (SAC) under the Habitats Directive. The marine area is designated for the habitats Large Shallow Inlet and Bay, Reef and Submerged Caves. The bay supports a variety of sub-tidal and intertidal sedimentary and reef habitats including habitats that are sensitive to pressures, which might arise from fishing and aquaculture, such as Maërl (corraline algae), seagrass and kelp reefs. The area is also designated for and supports significant numbers of Harbour Seal and Otter. Conservation Objectives for these habitats and species were identified by NPWS (2013a) and relate to the requirement to maintain habitat distribution, structure and function, as defined by characterizing (dominant) species in these habitats. For designated species the objective is to maintain various attributes of the populations including population size, cohort structure and the distribution of the species in the Bay. Guidance on the conservation objectives is provided by NPWS (2013b).

2.2 Activities in the SAC

Aquaculture includes the production of shellfish and finfish. The main aquaculture activity is suspended long-line mussel (*Mytilus edulis*) culture. Oyster culture involves the culture of the Pacific oyster (*Crassostrea gigas*) on trestles in intertidal areas. Clam and Scallop culture are both licensed in the area but are not currently active. There are four finfish (*Salmo salar*) farm sites currently active within the SAC.

The profile of the aquaculture industry in the Kenmare River, used in this assessment, was prepared by BIM and is derived from the list of licence applications received by DAFM and provided to the Marine Institute for assessment in March 2019.

A range of fishing activities occur in Kenmare River including potting, dredging and trawling for shellfish, demersal fish and pelagic fish. Other activities include, intertidal seaweed harvesting as well as seal watching tourism activity.

2.3 The Appropriate Assessment Process

The function of an appropriate assessment and risk assessment is to determine if the ongoing and proposed aquaculture and fisheries activities are consistent with the Conservation Objectives for the Natura site or if such activities will lead to deterioration in the attributes of the habitats and species over time and in relation to the scale, frequency and intensity of the activities. NPWS (2013b) provide guidance on interpretation of the Conservation Objectives which are, in effect, management targets for habitats and species in the SAC. This guidance is scaled relative to the anticipated sensitivity of habitats and species to disturbance by the proposed activities. Some activities are deemed to be wholly inconsistent with long term maintenance of certain sensitive habitats while other habitats can tolerate a range of activities. For the practical purpose of management of sedimentary habitats a 15% threshold of overlap between a disturbing activity and a habitat is given in the NPWS guidance. Below this threshold disturbance is deemed to be non-significant. Disturbance is defined as that which leads to a change in the characterizing species of the habitat (which may also indicate change in structure and function). Such disturbance may be temporary or persistent in the sense that change in characterizing species may recover to pre-disturbed state or may persist and accumulate over time.

The appropriate assessment and risk assessment process is divided into a number of stages consisting of a preliminary risk identification, and subsequent assessment (allied with mitigation measures if necessary) which are covered in this report. The first stage of the process is an initial screening wherein activities which cannot have, because they do not spatially overlap with a given habitat or have a clear pathway for interaction, any impact on the conservation features and are therefore excluded from further consideration. The next phase is the Natura Impact Statement (NIS) where interactions (or risk of) are identified. Further to this, an assessment on the significance of the likely interactions between activities and conservation features is conducted. Mitigation measures (if necessary) will be introduced in situations where the risk of significant disturbance is identified. In situations where there is no obvious mitigation to reduce the risk of significant impact, it is advised that caution should be applied in licencing decisions. Overall the Appropriate Assessment is both the process and the assessment undertaken by the competent authority to effectively validate this Screening Report and/or NIS. It is important to note that the screening process is considered conservative, in that other activities which may overlap with habitats but which may have very benign effects are retained for full assessment. In the case or risk assessments consequence and likelihood of the consequence occurring are scored categorically as separate components of risk. Risk scores are used to indicate the requirement for mitigation.

2.4 Data Supports

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

2.5 Findings

Aquaculture and Habitats:

The appropriate assessment and risk assessment finds that the majority of activities, at the current and proposed or likely future scale and frequency of activity are consistent with the Conservation Objectives for the Annex 1 habitats. The following are the exceptions:

1. Within the Kenmare River SAC the culture (licensed) of Scallops (*Pecten maximus*) on the seabed overlaps with three keystone communities, *Zostera* dominated community, Maerl dominated community and *Pachycerianthus multiplicatus* community. This activity is deemed disturbing to such community types. As key contributors to biodiversity and being sensitive to

[1] NPWS Geodatabase Ver: September 2013 - http://www.npws.ie/mapsanddata/habitatspeciesdata/

disturbance these community types are afforded a high degree of protection and no overlap with a disturbing activity can be tolerated.

2. Maerl dominated community occurs in certain areas (Ardgroom and Killmakilloge Harbours) which are outside of the Qualifying Interests for which the Kenmare River SAC was designated but are still within the SAC boundary. Maerl, the characterising species of this community, is listed as an Annex V species and as it is within the SAC boundary it must be afforded protection. Suspended mussel culture in Ardgroom Harbour overlaps this community type and is considered disturbing. As a key contributor to biodiversity and being sensitive to disturbance this community types is afforded a high degree of protection and no overlap with a disturbing activity can be tolerated.

Aquaculture and Species:

- It is acknowledged in this assessment that the favourable conservation status of the Harbour seal (*Phoca vitulina*) has been achieved given current levels of aquaculture production within the SAC. On this basis, the current levels of licenced aquaculture (existing) are considered non-disturbing to harbour seal conservation features. The following is one exception:
    - Aquaculture activity (oyster farm) overlapping Harbour Seal moulting site in Coongar Harbour. It is recommended that the site boundaries be redrawn to exclude the harbour seal haul-out location.
- The aquaculture activities proposed do not pose a threat to the Otter or migrating salmon in the Kenmare River SAC.

Fisheries and Habitats:

- Pot fisheries may pose a high risk to sensitive habitats (Zostera and Maerl) in Kenmare Bay and a low-moderate risk (depending on level of activity) to kelp communities
- Depending on intensity of activity demersal trawling may impact muddy sand communities in outer Kenmare Bay
- Scallop dredging poses a risk to faunal reef communities in Kenmare Bay.

Fisheries and Species:

- Although there is a risk of by-catch of harbour seal in set net fisheries in outer Kenmare Bay and in midwater trawl fisheries in the inner Bay this is unlikely to impact the Harbour Seal population in Kenmare. Sprat fisheries occur sporadically in Kenmare Bay and may temporarily reduce prey availability for Harbour Seal. This is unlikely to have significant effects on the Harbour Seal population
- Otters may occur as by-catch in trammel nets and pots fished in shallow water (<5m depth). As pots are usually deployed in waters deeper than 5m the risk of by-catch is thought to be very low and insignificant to otter populations in Kenmare

3. Introduction

This document assesses the potential ecological interactions of aquaculture and fisheries activities within the Kenmare River SAC (site code 2158) on the Conservation Objectives (COs) of the site.
The information upon which this assessment is based is a list of applications and extant licences for aquaculture activities administered by the Department of Agriculture Food and Marine (DAFM) and forwarded to the Marine Institute as of August 2013; as well as aquaculture and fishery profiling information provided on behalf of the operators by Bord Iascaigh Mara. The spatial extent of aquaculture licences is derived from a database managed by the DAFM[2] and shared with the Marine Institute.

4. Conservation Objectives for Kenmare River SAC (002158)

The appropriate assessment of aquaculture in relation to the Conservation Objectives for Kenmare River SAC is based on Version 1.0 of the objectives (NPWS 2013a - Version 1 April 2013) and supporting documentation (NPWS 2013b - Version 1 March 2013). The spatial data for conservation features was provided by NPWS[3].

4.1 The SAC Extent

Kenmare River is a long and narrow south-west facing bay situated in the south west of Ireland. Kenmare River has an exceptional complement of marine and terrestrial habitats associated with exposed coasts and ultra-sheltered bays. Numerous islands and inlets along the length of the bay provide areas of additional shelter in which a variety of habitats occur. Kenmare River SAC is designated for the marine Annex I qualifying interests of Large hallow inlets and bays (1160), Reefs (1170) and Submerged or partially submerged seacaves (8330). The Annex I habitat Large shallow inlets and bays is a large physiographic feature that may wholly or partly incorporate other Annex I habitats including Reefs and Submerged Seacaves within its area. A number of coastal habitats can also be found in the SAC, including Fixed coastal dunes with herbaceous vegetation (grey dunes), Vegetated sea cliffs of the Atlantic and Baltic coasts and shifting dunes along the shoreline with *Ammophilia arenaria* ("white dunes"). The SAC is also considered an important site for the two mammal species Harbour Seal (*Phoca vitulina*) and the Otter (*Lutra lutra*). The extent of the SAC is shown in Figure 1 below.

4.2 Qualifying Interests (SAC)

The SAC is designated for the following habitats and species (NPWS 2013a), as listed in Annex I and Annex II of the Habitats Directive:

- 1014 Marsh Snail *Vertigo angustior*

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[2] DAFM Aquaculture Database version Aquaculture: 11th Nov, 2013
[3] NPWS Geodatabase Ver: September 2013 - http://www.npws.ie/mapsanddata/habitatspeciesdata/

- 1160 Large shallow inlets and bays
- 1170 Reefs
- 1220 Perennial vegetation of stony banks
- 1230 Vegetated sea cliffs of the Atlantic and Baltic coasts
- 1303 Lesser Horseshoe Bat *Rhinolophus hipposideros*
- 1330 Atlantic salt meadows (Glauco-Puccinellietalia maritimae)
- 1355 Otter *Lutra lutra*
- 1365 Harbour seal *Phoca vitulina*
- 1410 Mediterranean salt meadows (*Juncetalia maritimi*)
- 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes")
- 2130 Fixed coastal dunes with herbaceous vegetation (grey dunes)
- 4030 European dry heaths
- 6130 Calaminarian grasslands of the *Violetalia calaminariae*
- 8330 Submerged or partially submerged sea caves

Constituent communities and community complexes recorded within the qualifying interest Annex 1 habitats (i.e. 1160 - Large Shallow inlets and Bays, 1170 - Reefs) are listed in NPWS (2013b) and illustrated in Figure 2 and consist of:

- Intertidal mobile sand community complex
- *Zostera*-dominated community
- Maërl-dominated community
- *Pachycerianthus multiplicatus* community
- Muddy fine sands dominated by polychaetes and *Amphiura filiformis* community complex
- Fine to medium sand with crustaceans and polychaetes community complex
- Coarse sediment dominated by polychaetes community complex
- Shingle
- Intertidal reef community complex
- *Laminaria*-dominated community complex
- Subtidal reef with echinoderms and faunal turf community complex

The Kenmare River SAC is designated for the Harbour seal (*Phoca vitulina*) and has been the subject of annual monitoring surveys during the moulting season (August-September) from 2009-2011 (NPWS 2010, 2011, 2012). Recent estimates of harbour seal populations at the site (inner Kenmare River) are 310 in 2009, 324 in 2010, and 309 in 2011. Two sites located in outer Kenmare River, Illaunsillagh and Cove Harbour/West Cove, were also surveyed. Estimates of seal populations at these outer sites rose from 21 (2009) to 37 (2011) and from 31 (2010) to 50 (2011) respectively.

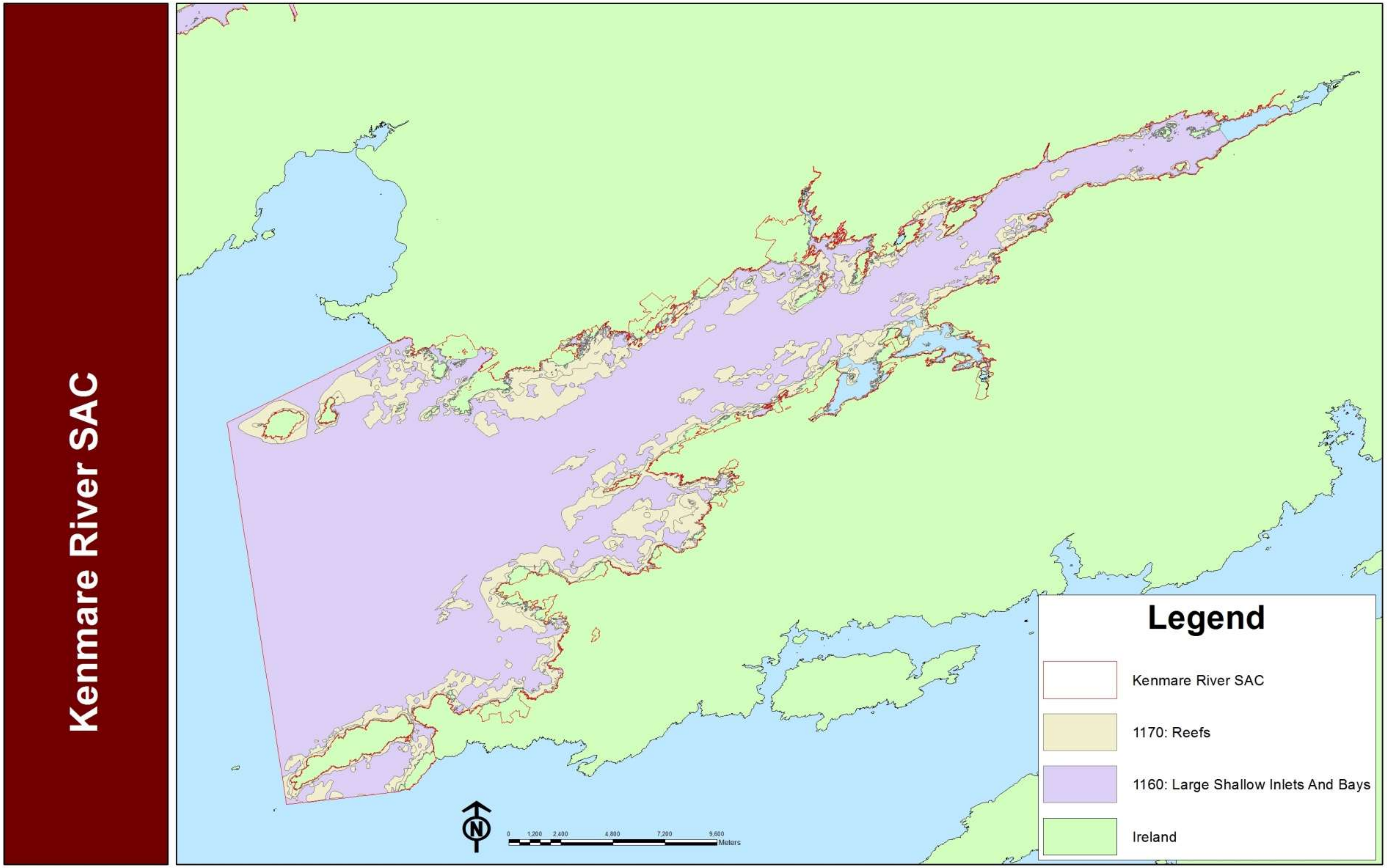

Figure 1: The extent of the Kenmare River SAC (Site Code 002158) and qualifying interest 1170 Reef and 1160 Large Shallow Inlet and Bay.

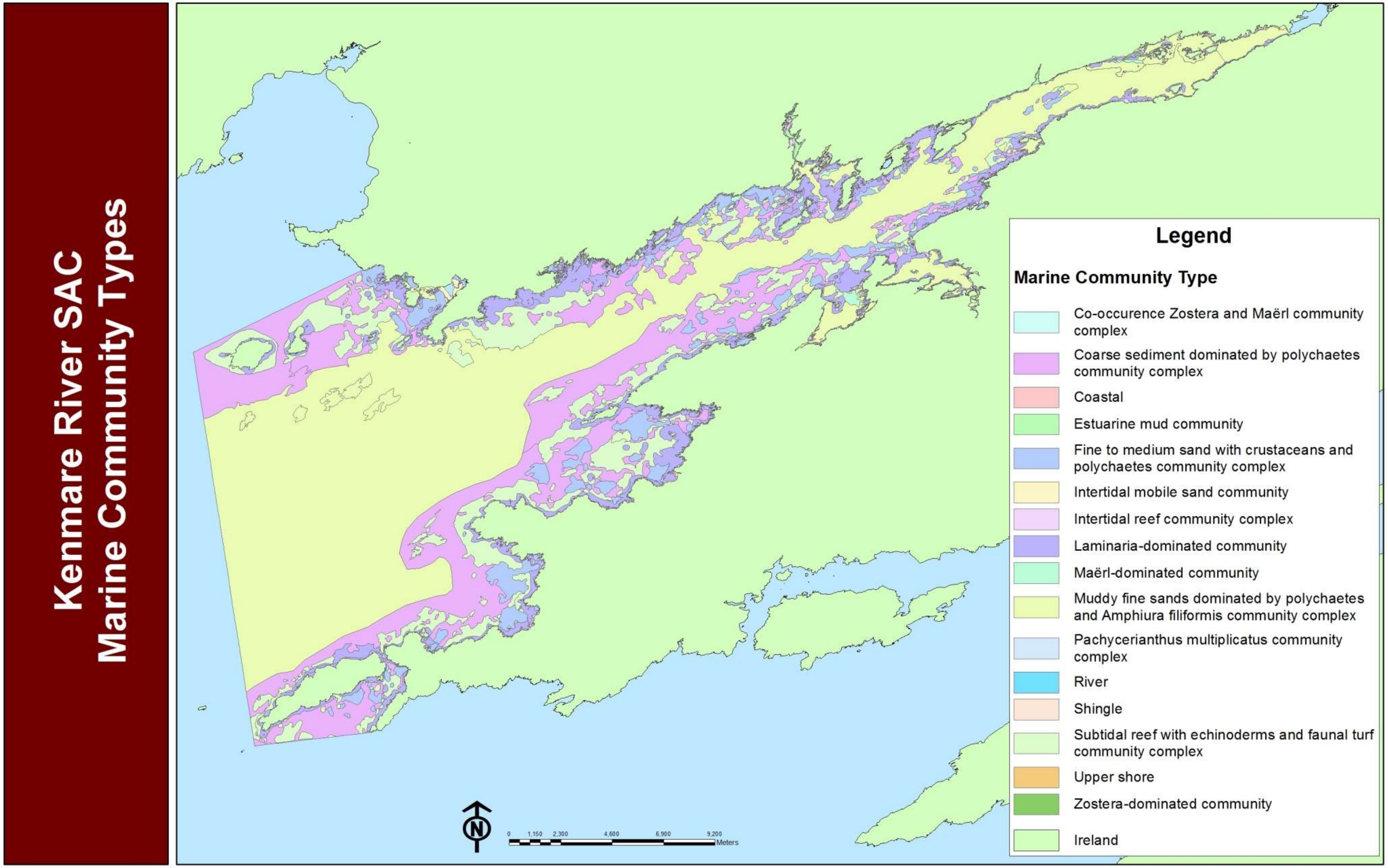

Figure 2. Principal benthic communities recorded within the qualifying interests Large shallow inlets and bays Reefs and Submerged or partially submerged sea caves within the Kenmare River SAC (Site Code 002158) (NPWS 2013a).

Based on recent reports (Cronin *et al*., 2004; Heardman *et al*., 2006; Cronin et al, 2008, NPWS 2010, 2011, 2012) the Kenmare River is deemed important both on a regional and on a national scale regarding its Harbour seal population.

A number of different locations have been identified within the SAC (NPWS 2013a) and are considered important to the overall welfare and health of the Harbour seal populations at the site. Figure 3 identifies these locations and distinguishes between breeding, moulting and resting sites. A site naming convention based upon designated periods in the life cycle have been identified by the competent authority, i.e. NPWS (NPWS 2011; 2013b). Important periods are the pupping season (May-July) and moulting season (August-September) and both periods and locations are considered important periods to the overall health of the population in the SAC and that any disturbance during these times should be kept to a minimum. Less information is known about resting period (October-April) and resting areas throughout the SAC. The resting locations provided in Figure 3 represent locations where seals have been observed, yet it must be noted that sheltered areas within the entire SAC are considered suitable habitat for resting seals (NPWS 2012, 2013a).

The Kenmare River SAC is designated for the Otter, *Lutra lutra*. The species is listed in Annex IV(a) of the habitats directive and is afforded strict protection. According to the NPWS (2009) although otter numbers have declined from 88% in 1980/81 to 70% in 2004/05, otters remain widespread in Ireland.

4.3 Conservation Objectives for Kenmare River SAC

The conservation objectives for the qualifying interests (SAC) were identified in NPWS (2013a). The natural condition of the designated features should be preserved with respect to their area, distribution, extent and community distribution. Habitat availability should be maintained for designated species and human disturbance should not adversely affect such species. The features, objectives and targets of each of the qualifying interests within the SAC are listed in Table 1 below.

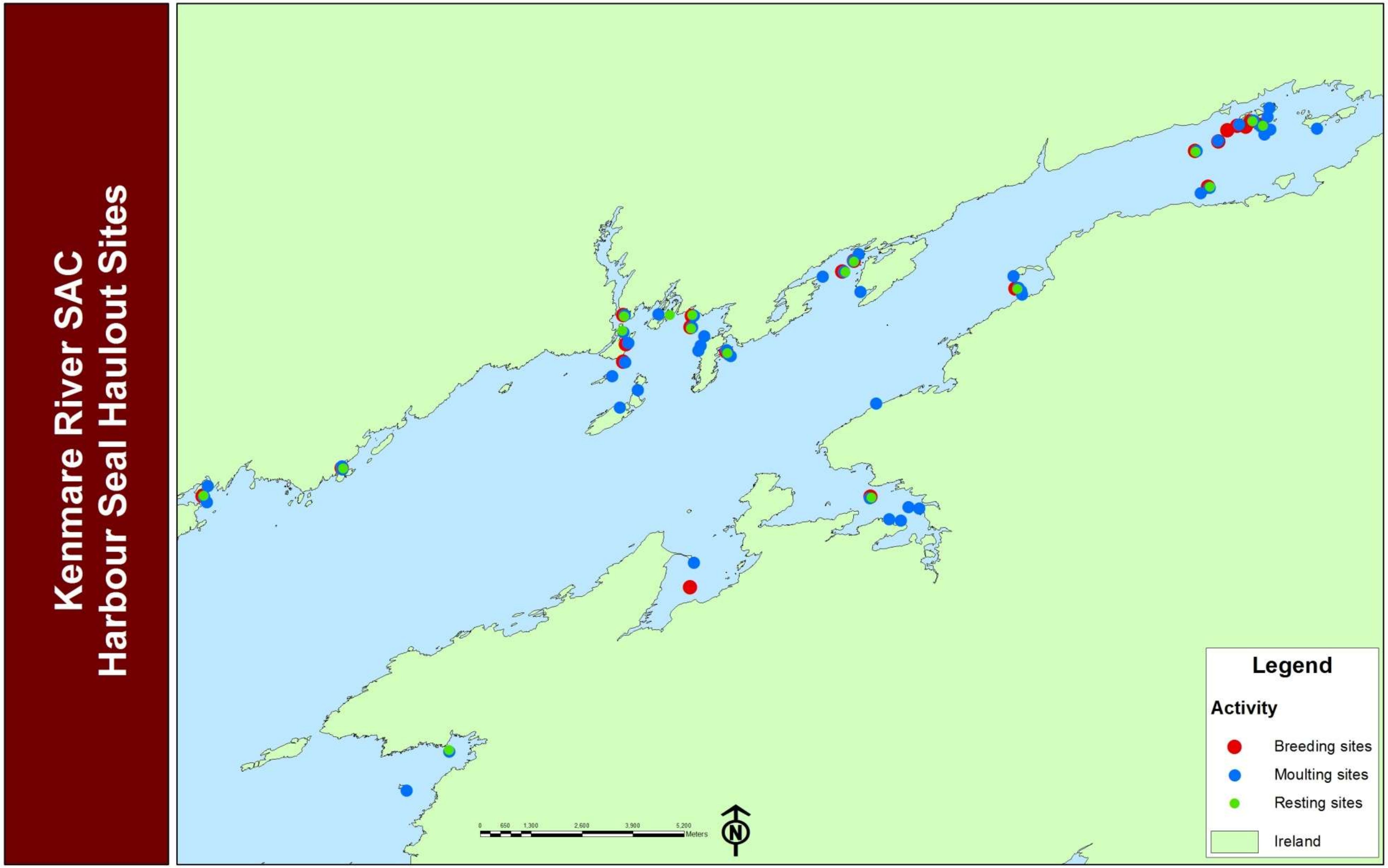

Figure 3 Harbour Seal (*Phoca vitulina*) locations in Kenmare River SAC (Site Code 002158).

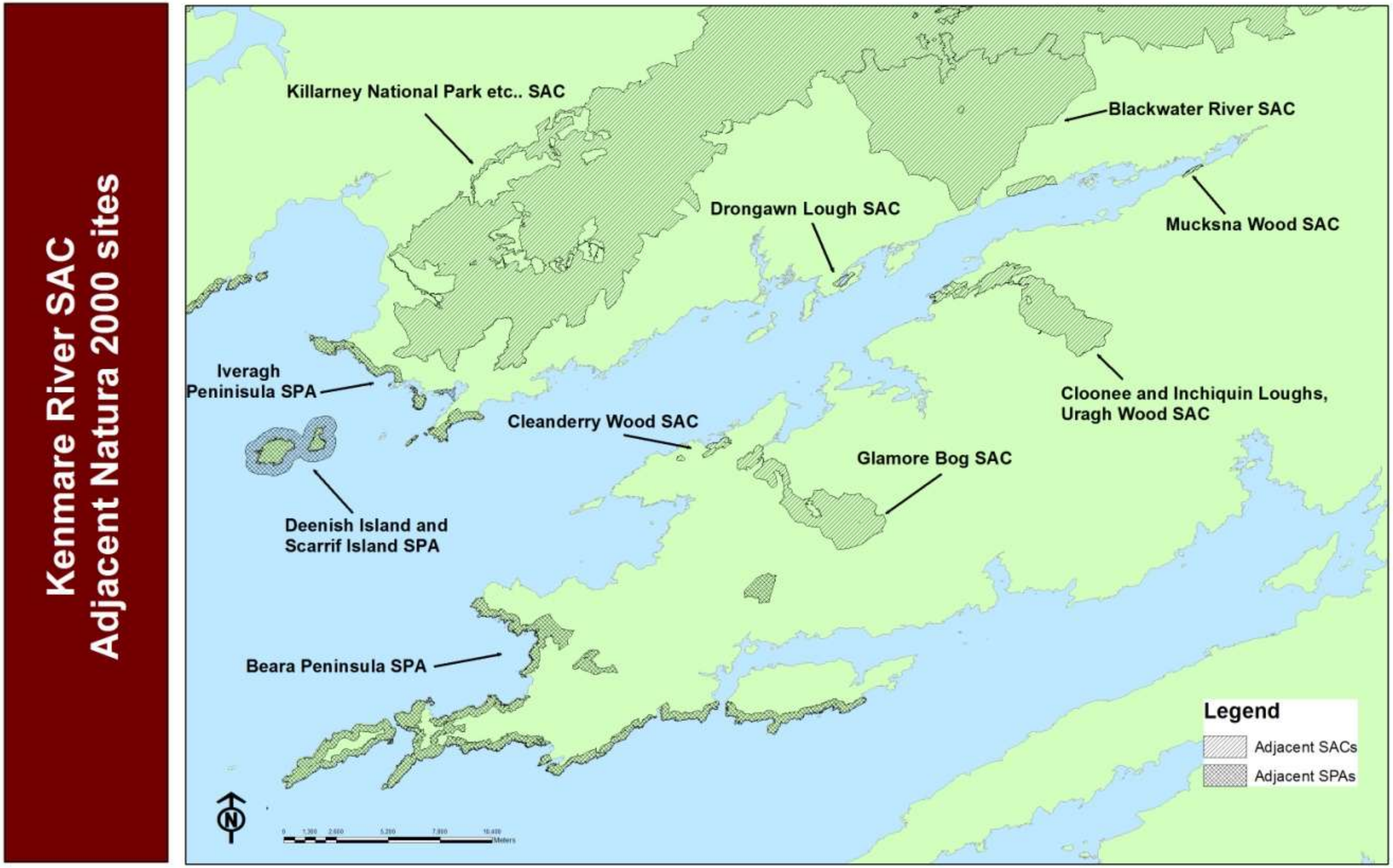

Figure 4. Natura 2000 sites adjacent to the Kenmare River SAC.

Table 1: Conservation objectives and targets for marine habitats and species in Kenmare River SAC (Site Code 002158) (NPWS 2013a, 2013b). Annex I and II features listed in bold.

Feature (Community Type)	Objective	Target(s)
Large shallow inlets and bays	Maintain favourable conservation condition	39,322ha;Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
(Intertidal mobile sand community complex)	Maintain favourable conservation condition	63.07ha; Maintained in a natural condition
(*Zostera* dominated communities)	Maintain favourable conservation condition	20.04ha; Maintain natural extent and high quality of *Zostera* dominated communities
(Maërl-dominated community)	Maintain favourable conservation condition	46.82ha; Maintain natural extent and high quality of Maërl dominated communities
(*Pachycerianthus multiplicatus* community)	Maintain favourable conservation condition	6.23ha; Maintain natural extent and high quality of *Pachycerianthus multiplicatus* community
(Muddy fine sands dominated by polychaetes and *Amphiura filiformis* community complex)	Maintain favourable conservation condition	20,141.20ha; Maintained in a natural condition
(Fine to medium sand with crustaceans and polychaetes community complex)	Maintain favourable conservation condition	1987.75ha; Maintained in a natural condition
(Coarse sediment dominated by polychaetes community complex)	Maintain favourable conservation condition	8,309.80ha; Maintained in a natural condition
(Shingle)	Maintain favourable conservation condition	1.42ha; Maintained in a natural condition
(Intertidal reef community complex)	Maintain favourable conservation condition	525.46ha; Maintained in a natural condition
(*Laminaria*-dominated community complex)	Maintain favourable conservation condition	3,356.63ha; Maintained in a natural condition
(Subtidal reef with echinoderms and faunal turf community complex)	Maintain favourable conservation condition	4805.86ha; Maintained in a natural condition
Reefs	Maintain favourable conservation condition	9,196ha; The distribution and permanent area is stable or increasing, subject to natural processes.
(Intertidal reef community complex)	Maintain favourable conservation condition	680.26ha; Maintained in a natural condition
(Subtidal reef with echinoderms and faunal turf community complex)	Maintain favourable conservation condition	4,835.43ha; Maintained in a natural condition
(*Laminaria*-dominated community complex)	Maintain favourable conservation condition	3,676.57ha; Maintained in a natural condition
Perennial vegetation of stony banks	Maintain favourable conservation condition	Area unknown; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.

Feature (Community Type)	Objective	Target(s)
Vegetated sea cliffs of the Atlantic and Baltic coasts	Maintain favourable conservation condition	>72.2ha; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Maintain favourable conservation condition	2.65ha; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species.
Mediterranean salt meadows (*Juncetalia maritimi*)	Maintain favourable conservation condition	17.90ha;Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species
Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes")	Maintain favourable conservation condition	1.67ha;Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species
Fixed coastal dunes with herbaceous vegetation (grey dunes)	Maintain favourable conservation condition	20.41ha; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species
European dry heaths	Maintain favourable conservation condition	>300ha; Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species and disturbance
Calaminarian grasslands of the *Vioetalia claminariae*	Maintain favourable conservation condition	3.1ha: Targets are identified that focus on a wide range of attributes with the ultimate goal of maintaining function and diversity of favourable species and managing levels of negative species and disturbance (soil toxicity).
Submerged or partially submerged sea caves	Maintain favourable conservation condition	Area unknown; Targets relate to maintaining distribution and managing human activities.
Marsh Snail *Vertigo angustior*	Maintain favourable conservation condition	A single site is identified for this species and targets relate to maintaining adult and sub-adult densities and overall habitat quality.
Otter *Lutra lutra*	Restore favourable conservation conditions	Maintain distribution - 88% positive survey sites.

Feature (Community Type)	Objective	Target(s)
		2748ha; No significant decline in extent of marine habitat; Couching sites and holts - no significant decline and minimise disturbance: Fish biomass - No significant decline in marine fish species in otter diet. Barriers to connectivity - No significant increase.
Harbour Seal *Phoca vitulina*	Maintain favourable conservation condition	The range of use within the site should not be restricted by artificial barriers; all sites should be maintained in natural condition; human activities should occur at levels that do not adversely affect harbour seal population at the site.
Lesser Horseshoe Bat (*Rhinolophus hipposideros*)	Maintain favourable conservation condition	The range of use within the site should not be restricted by artificial barriers; all sites should be maintained in natural condition; human activities should occur at levels that do not adversely affect the Lesser Horsehoe Bay population at the site.

4.4 Screening of Adjacent SACs or for *ex-situ* effects

In addition to the Kenmare River SAC there are a number of other Natura 2000 sites proximate to the proposed activities (Figure 4). The characteristic features of these sites are identified in Table 2 where a preliminary screening is carried out on the likely interaction with aquaculture activities based primarily upon the likelihood of spatial overlap. As it was deemed that there are no *ex situ* effects and no effects on features in adjacent SACs all qualifying features of adjacent Natura 2000 sites were screened out.

Table 2 Natura Sites adjacent to Kenmare River SAC and qualifying features with initial screening assessment on likely interactions with aquaculture activities.

NATURA SITE	QUALIFYING FEATURES [HABITAT CODE]	AQUACULTURE INITIAL SCREENING
Old Domestic Building , Dromore Wood SAC (000353)	Lesser Horseshoe Bat (*Rhinolophus hipposideros*) [1303]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Cleanderry Wood SAC (001043)	Killarney Fern *Trichomanes speciosum* [1421]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Old sessile oak woods with Ilex and Blechnum in the British Isles [91A0]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Cloonee and Inchiquin Loughs, Uragh Wood SAC (001342)	Kerry slug *Geomalacus maculosus* [1024]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Lesser horseshoe bat *Rhinolophus hipposideros* [1303]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Killarney fern *Trichomanes speciosum* [1421]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Slender naiad *Najas flexilis* [1833]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*) [3110]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis

NATURA SITE	QUALIFYING FEATURES [HABITAT CODE]	AQUACULTURE INITIAL SCREENING
	Old sessile oak woods with Ilex and Blechnum in British Isles [91A0]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Mucksna Wood SAC (001371)	Old sessile oak woods with Ilex and Blechnum in British Isles [91A0]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Glanmore Bog SAC (001879)	Freshwater pearl mussel (*Margaritifera margaritifera*) [1029]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Killarney fern (*Trichomanes speciosum*) [1421]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*) [3110]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Northern Atlantic wet heaths with *Erica tetralix* [4010]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Blanket bog (*active only) [7130]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Drongawn Lough SAC (002187)	Coastal lagoons [1150]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis

NATURA SITE	QUALIFYING FEATURES [HABITAT CODE]	AQUACULTURE INITIAL SCREENING
Blackwater River (Kerry) SAC (002173)	Kerry slug (*Geomalacus maculosus*) [1024]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Freshwater pearl mussel (*Margaritifera margaritifera*) [1029]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Salmon (*Salmo salar*) [1106]	Migrating salmon passing through Kenmare River SAC and could interact with activities covered in this assessment- **carry forward to Section 8.**
	Lesser horseshoe bat (*Rhinolophus hipposideros*) [1303]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
	Otter (*Lutra lutra*) [1355]	Otter may migrate into Kenmare River SAC and could interact with aquaculture and fisheries activities **– carry forward to Section 8.**
	European dry heaths [4030]	No spatial overlap with aquaculture and fisheries activities within Kenmare River SAC – excluded from further analysis
Iveragh Peninsula SPA (004154)	Fulmar (*Fulmarus glacialis*) [A009]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis [4]
	Peregrine (*Falco peregrinus*) [A103]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis

[4] http://www.npws.ie/media/npwsie/content/images/protectedsites/sitesynopsis/SY004154.pdf

NATURA SITE	QUALIFYING FEATURES [HABITAT CODE]	AQUACULTURE INITIAL SCREENING
	Kittiwake (*Rissa tridactyla*) [A188]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
	Guillemot (*Uria aalge*) [A199]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
	Chough (*Pyrrhocorax pyrrhocorax*) [A346]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
Beara Peninsula SPA (004155)	Fulmar (*Fulmarus glacialis*) [A009]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis [5]
	Chough (*Pyrrhocorax pyrrhocorax*) [A346]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
Deenish Island and Scariff Island SPA (004175)	Fulmar (*Fulmarus glacialis*) [A009]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis [6]
	Manx Shearwater (*Puffinus puffinus*) [A013]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis

[5] http://www.npws.ie/media/npwsie/content/images/protectedsites/sitesynopsis/SY004155.pdf
[6] http://www.npws.ie/media/npwsie/content/images/protectedsites/sitesynopsis/SY004175.pdf

NATURA SITE	QUALIFYING FEATURES [HABITAT CODE]	AQUACULTURE INITIAL SCREENING
	Storm Petrel (*Hydrobates pelagicus*) [A014]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
	Lesser Black-backed Gull (*Larus fuscus*) [A183]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis
	Arctic Tern (*Sterna paradisaea*) [A194]	Breeding sites have no spatial overlap with aquaculture and fisheries activities within Kenmare River SAC; Risk of disturbance is minimal – excluded from further analysis

5. Details of the proposed plans and projects

5.1 Aquaculture

Aquaculture in the Kenmare River SAC focuses on shellfish species (mussels, oysters scallops and clams) and finfish (Salmon) (Figures 5 and 6). Mussels are the predominant shellfish species cultured within the SAC. Small quantities of oysters are produced; while Scallops and Clams, although licensed, are not currently produced in the area. There are also six locations dedicated to the culture of Atlantic Salmon. Descriptions of spatial extents of existing and proposed activities within the qualifying interests of the Kenmare River SAC were calculated using coordinates of activity areas in a GIS. The spatial extent of the various aquaculture activities (current and proposed) overlapping the habitat features is presented in Table 3 (data provided by DAFM).

5.1.1 Oyster Culture

Oyster farming within Kenmare River is a form of intensive culture which has been taking place since the early 1990s. A single species forms the basis of oyster aquaculture operation in the Kenmare River SAC, i.e. the Pacific oyster, *Crassostrea gigas.* The seed is cultivated using the bag and trestle method, either to half-grown or fully-grown size. The bag and trestle method uses steel table-like structures which rise from the shore to just above knee height on the middle to lower intertidal zone, arrayed in double rows with wide gaps between the paired rows to allow for access. The trestles hold HDPE bags approximately 1m by 0.5m by 10cm, using rubber and wire clips to close the bags and to fasten them to the trestles. When first put to sea, there may be up to 2000 oysters in a single bag, but as they grow and are graded this number is gradually reduced. Over the course of the two or three years that it takes an oyster to reach saleable size, the density is reduced until market ready oysters, of approximately 100g each (when grown to full size) are being grown in bags of approximately 100 oysters per bag. The bags need to be shaken, turned and re-secured occasionally to prevent build-up of fouling and to ensure the growing oysters maintains a good marketable shape. This usually takes place once on each tidal cycle, when maximum exposure of the shore allows safe access to all trestles. It is most important during the summer months when plankton, the oysters' food, is abundant and oyster growth rates are at their optimum. Oysters are grown on in these bags to half-grown or full grown size for up to three years, and will be graded two or three times over the course of each summer.

There are four sites in operation, three in Templenoe and one in Coongar Harbour. These operations are relatively small, currently producing less than 30 tonnes annually, they are classified as free from the herpes virus and at the moment the operators are buying in seed from Seasalter, both diploid and triploid, depending on availability. This availability means that there is currently no generalised production cycle. Sites are accessed at low tide using a tractor and trailer, by a public road near Templenoe and by boat in Coongar Harbour.

There are a number of applications for new licences for bag and trestle oyster culture, in Killmakilloge and Ardgroom Harbour, which would be accessed by boat from the local piers and one on the south shore of Kenmare River, near Killaha East which would be accessed by shore from the applicants own property. Some of these are for multi species licences, to include native oysters, mussels, but still using the bag and trestle method of cultivation.

5.1.2 Rope Mussels

There are a number of very productive locations for suspended long-line mussel farming in Kenmare River, namely Killmakilloge Harbour (600 – 1000 tonnes), Ardgroom Harbour, including Coosmore and Cleanderry Harbour (700 – 1100 tonnes) and Coongar Harbour, including Sneem Harbour (150 – 200 tonnes). All of the farms are locally owned, providing quite large scale local employment. The main piers in use are located close to these growing areas.

The culture method involves placing, an often re-usable, settlement media (rope, strap, mesh) in the water column, known as a 'dropper' on which natural juvenile mussels settle, depending on a number of seasonal and local factors this takes place in April, May or June, the naturally collected mussel seed is then on-grown for typically 18-24 months before being harvested as per market requirements and in line with shellfish and water quality parameters. Some of the larger farmers operate as contract service providers, carrying out the harvesting for the smaller farmers, using their purpose built work barges, although for the most part the farmers work their own farms using smaller converted fishing vessels. As these mussels grow the 'droppers' are often moved to grow-out areas, or remain in situ. Some farms grade the mussels during the 18-24 months, using the "New Zealand" continuous rope system, whereby the mussels are re-packed at a specific density using bio-degradable cotton mesh around the rope, the mesh rots away after the mussels have re-attached using their byssal threads. All of the long-lines in use are double head rope longlines, constructed from polypropylene mostly of 110m in length, with typically 30 x 210-250l floatation units (mostly grey in colour) and anchored at each end with 2.5 tonne concrete weights. In general the long-line density is no greater than 3 lines per hectare. In Ardgroom Harbour the mussel farmers, through the CLAMS process set a self-imposed stocking density of 2 longlines per hectare and a dropper limit of 406 per line.

There are a number of long-line licence applications in the traditional areas of Ardgroom, Killmakilloge and Coongar Harbours as well as an expansion into deeper, more exposed waters of Kenmare River and in Coulagh Bay. A number of these newer long-line licence applications are for multi-species licences, to include mussels, oysters and native seaweeds.

A single trial site is currently in operation to establish the technical feasibility of a novel rope cultivation system for a mussel longline system in the main body of Kenmare River (Figure 7). The experimental deployment includes 3 mussel lines of 40m (at surface) 180m (total length including full length of moorings) in the proposed site for a period of 18 months. Drop lines (per surface line) are seeded with mussels (7-10mm locally sourced) and suspended at a range of depths between 5m and 35m. Monthly measurements of growth are to be taken. Environmental monitoring will include high frequency data on wave height, current speed and direction, temperature and salinity, and periodic manual observations will also be conducted (e.g. plankton tows, water samples for chlorophyll measurements). Following the trial period of 18 months all field trial equipment will be removed from the area.

5.1.3 Salmon Culture

Salmon (*Salmo salar*) is currently produced at 4 sites within the Kenmare River SAC. Five sites are licensed to produce salmon, one of which is also licensed to produce Rainbow trout (*Oncorhynchus mykiss*). There is also one licence application for salmon production.

Marine Harvest Ireland (MHI) operates two sites, Inisfarnard and Deenish. At both sites there is space for fourteen 128m circumference net pens, with 15m sides. The cubic capacity of each net pen is 19,600m^3, leading to an overall volume of 274,400m^3 and at maximum allowable stocking density, a potential standing stock of 2,744 tonnes. Each site also has a feed barge, moored on site, which can hold a maximum of 200 tonnes of feed. The feed barge can feed the stock automatically throughout the day, each net pen has cameras installed to monitor the fish, optimising feed conversion rate and minimising waste. The sites operate on a two year annual alternate site stocking cycle, inputting 800,000 smolts, to each site alternately and harvesting them in year two from months 16 to 22. The site is then left fallow for two months before next smolt input. These sites are accessed from piers in Castletownbere, Travarra and Ballycrovane.

Murphy's Irish Seafood Ltd operates the other two sites, St. Killians and Doon Point. St Killians, in Killmakilloge Harbour, a 160 tonne licenced site (leased from St. Killian's Salmon Ltd), has three 70m net pens and is currently operating as a smolt site holding the fish for one year before being transferred to a main grower site. The Doon Point site is currently fallow, but has a licenced capacity of similar to the MHI sites above. These sites are accessed from Cleandra and Killmakilloge in Kenmare River and Gearhies in Bantry Bay.

The smolts for these sites come from a number of sources. Smolt is the name given to juvenile salmon, when they would naturally travel from fresh water, where they are hatched and develop, approximately for one year, to salt water for feeding and further growth before returning to the same fresh water to breed. The smolts for the MHI operation are currently produced in the MHI freshwater facilities in Donegal, namely Altan and Pettigoe. Murphy's Irish Seafood Ltd, whilst producing most of their smolt requirements from their Borlin hatchery also buy in smolt from Derrylea Holdings Ltd. All of these smolts are trucked from the freshwater facilities to a well boat for delivery to the sea sites. Once at sea the smolts are reared in nets suspended from circular floating structures known as pens. These are moored in groups, in locations where there are strong water flows in order to provide the stock with optimum environmental conditions, as salmon are extremely sensitive to pollution and only grow if the waters in which they live are clean and well oxygenated. The smolts are initially fed by hand but as they grow, mechanical feed systems are used.

All sites are operating according to EU Organic Aquaculture standards[7], which include low stocking densities and the use of organically certified food. The nets are made of knotless netting and no anti-fouling treatment is allowed, nets are either cleaned *in-situ* using pressurised water systems or alternatively when the need arises the nets are changed. Regular dive inspections are carried out on the nets and moorings.

5.1.4 Scallops

Within the Kenmare River SAC, there are eleven sites licensed for the production of scallops and also two applications (Ballycrovane and Killmakilloge Harbours). None of the licensed scallop sites are currently active. Scallops are dredged from the seafloor within these licensed areas. There is little or no intervention to improve stocks. The activities effectively equate to a wild fishery.

At the two application sites (Killmakillogue and Ballycrovane Harbours), juvenile scallops would be purchased either from a hatchery or from wild collection and broadcast on the seabed; these would then be left to grow, to be harvested by divers.

5.1.5 Clams

There is a single licence for clam cultivation in conjunction with oysters. Clams have never been farmed on site and currently the site is being used to farm oysters on bag and trestle. If clams were to be farmed, they would be seeded in the ground, under nets, the clams would then be raked by hand for grading and harvesting.

5.2 Description of Fishing Activities

5.2.1. Pot fisheries

Six vessels less than 8m in length fish for lobster and crab along the coast from Ballinskelligs into Kenmare River using 1500 pots and a further 8 vessels under 10m in length fish 2500 pots in inner Kenmare. A further 19 vessels fishing 9500 pots fish for shrimp (*Palaemon serratus*) in inner Kenmare. Potting for prawns (Nephrops) occurs at the edge of trawling ground in outer and mid Kenmare (Fig. 7).

5.2.2. Dredge fisheries

Scallops are fished with dredges on the south shore of inner Kenmare.

5.2.3. Set net fisheries

Tangle netting for crayfish occurs at the outer edges of the SAC and in coastal waters to the north and south of the site (Fig. 8).

[7] http://www.bim.ie/our-services/grow-your-business/farmedfishqualitylabelling/organicassurancelabellingschemes/

5.2.4. Bottom trawl fisheries

Bottom trawl fisheries, targeting *Nephrops* and mixed demersal fish, occurs on fine sedimentary habitats in outer Kenmare River.

5.2.5. Pelagic fisheries

Pelagic trawling for sprat occurs in winter in inner Kenmare River (Fig. 9).

5.2.6. Hook and line fisheries

Inshore fishing vessels fish for Mackerel and Pollack in outer Kenmare River SAC in summer and autumn (Fig. 10)

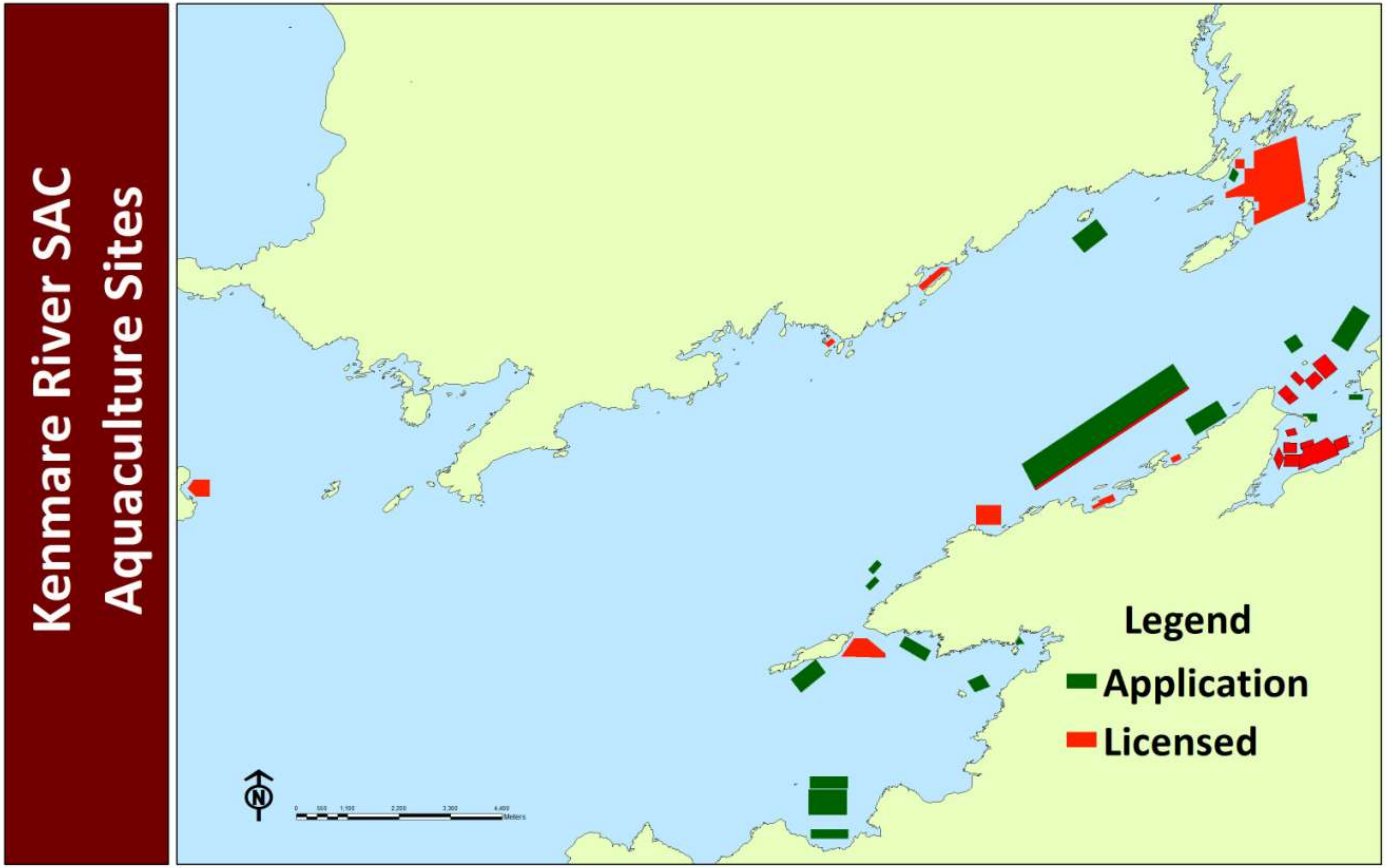

Figure 5 Aquaculture sites (Licenced and Applications) in western portion of Kenmare River SAC (Site Code 002158).

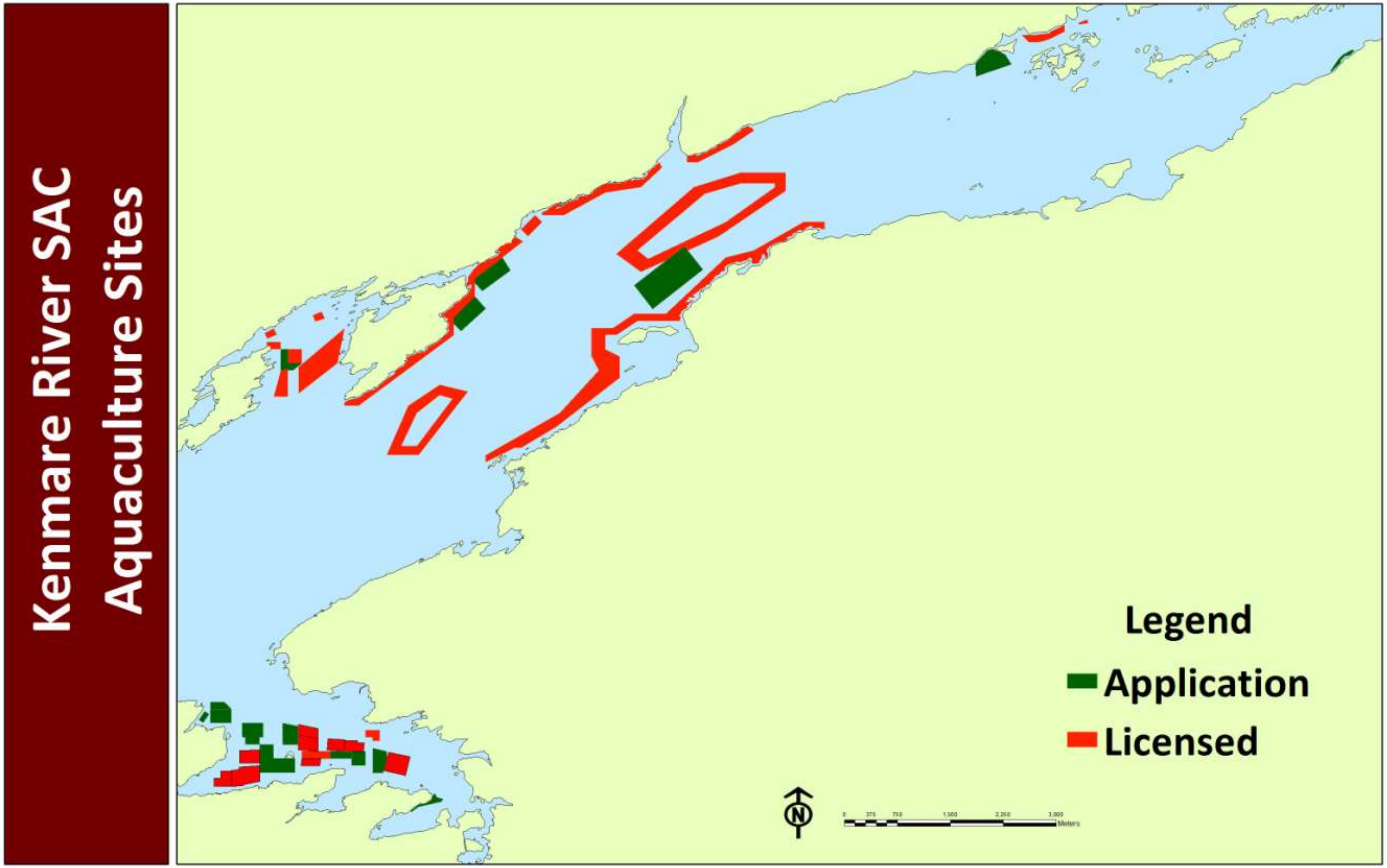

Figure 6 Aquaculture sites (Licenced and Applications) in eastern portion of Kenmare River SAC (Site Code 002158).

Table 3: Spatial extent (ha) of aquaculture activities overlapping with the qualifying interest (1160 Large shallow inlets and bays and 1170 Reefs) in Kenmare River SAC (Site Code 002158), presented according to culture species, method of cultivation and license status.

Species	Status	Location	1160 - Large shallow inlets and Bays 39,322ha		1170 – Reefs 9,196ha	
			Area (ha)	**% Feature**	**Area (ha)**	**% Feature**
Oysters	Licensed	Intertidal	7.53	0.02	1.54	0.02
Oysters	Application	Intertidal	27.56	0.07	44.50	0.48
Mussels	Licensed	Subtidal	46.97	0.12	41.39	0.45
Mussels	Application	Subtidal	483.48	1.23	134.43	1.46
Finfish	Licensed	Subtidal	62.67	0.16	12.13	0.13
Finfish	Application	Subtidal	31.89	0.08	14.50	0.16
Scallops	Licensed	Subtidal	473.10	1.20	209.10	2.27
Scallops	Application	Subtidal	1.87	4.76E-03	1.84	0.02
Totals			**1135.07ha**	**2.88%**	**459.43 ha**	**4.99%**

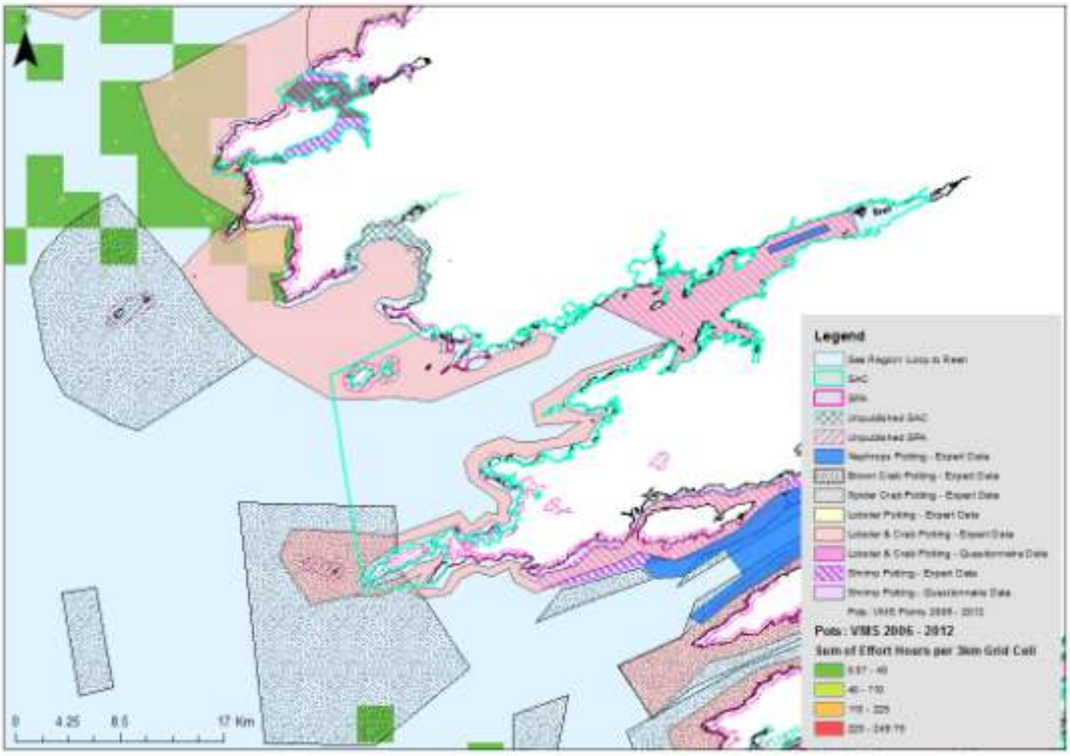

Figure 7. Pot fishing activity in the region of Kenmare River SAC

Figure 8. Set net fishing activity in the region of Kenmare River SAC

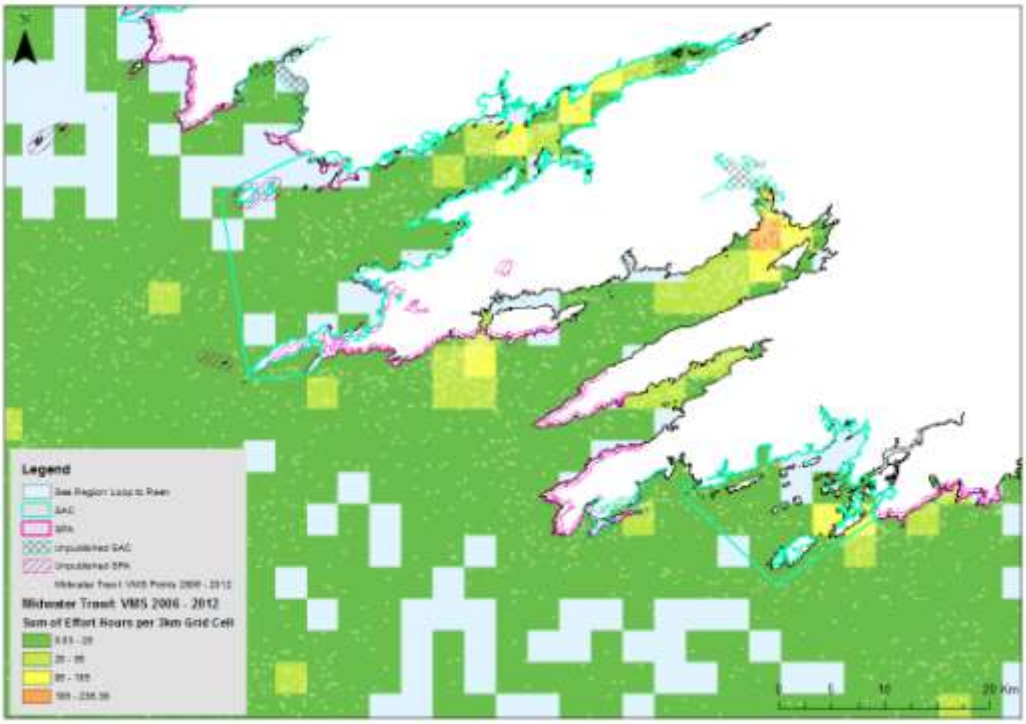

Figure 9. Pelagic fishing activity in the region of Kenmare River SAC

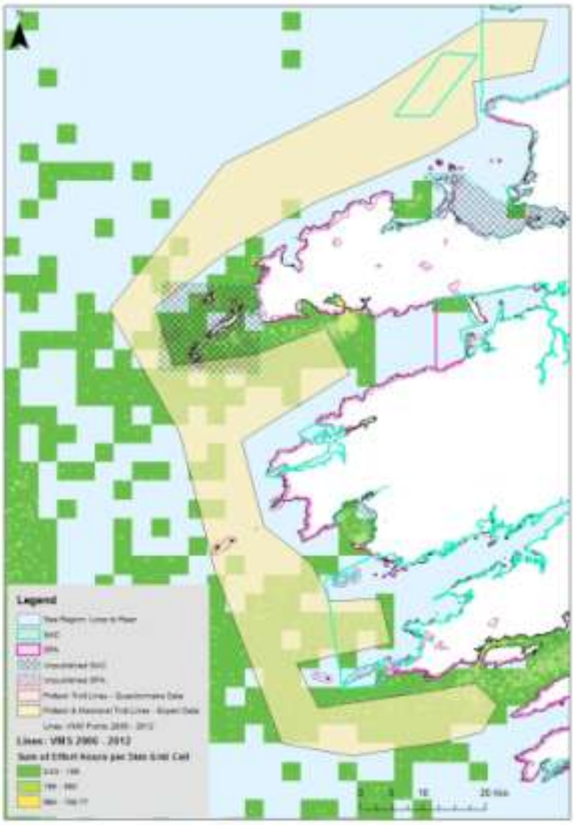

Figure 10. Hook and line fishing activity in the region of Kenmare River SAC

6. Natura Impact Statement for the Activities

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

6.1 Aquaculture

Within the qualifying interest of the Kenmare River SAC, the species cultured are:

- Mussels (*Mytilus edulis*) in suspended culture (Rope culture) in subtidal areas.
- Oysters (*Crassostrea gigas*), in suspended culture (bags & trestles) confined to intertidal areas.
- Scallops (*Pecten maxius*) subtidally on the seafloor.
- Clams (*Ruditapes philippinarum*) on the seafloor intertidally.
- Atlantic salmon (*Salmo salar*) in net pens.

Details of the potential biological and physical effects of these aquaculture activities on the habitat features, their sources and the mechanism by which the impact may occur are summarised in Table 4, below**.** The impact summaries identified in the table are derived from published primary literature and review documents that have specifically focused upon the environmental interactions of mariculture (e.g. Black 2001; McKindsey *et al*. 2007; NRC 2010; O'Beirn *et al* 2012; Cranford *et al* 2012; ABPMer 2013a-h).

Filter feeding organisms, for the most part, feed at the lowest trophic level, usually relying primarily on ingestion of phytoplankton. The process is extractive in that it does not rely on the input of feedstuffs in order to produce growth. Suspension feeding bivalves such as oysters and mussels can modify their filtration to account for increasing loads of suspended matter in the water and can increase the production of faeces and pseudofaeces (non-ingested material) which result in the transfer of both organic and inorganic particles to the seafloor. This process is a component of benthic-pelagic coupling (Table 3). The degree of deposition and accumulation of biologically derived material on the seafloor is a function of a number of factors discussed below.

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

Suspended Shellfish Culture: Suspended culture, may result in faecal and pseudo-faecal material falling to the seabed. In addition, the loss of culture species to the seabed is also a possibility. The degree to which the material disperses away from the location of the culture system (longlines or trestles) depends on the density of mussels on the line, the depth of water and the current regime in the vicinity. Cumulative impacts on seabed, especially in areas where assimilation or dispersion of pseudofaeces is low, may occur over time. A number of features of the site and culture practices will govern the speed at which pseudofaeces are assimilated or dispersed by the site. These relate to:

- Hydrography – will govern how quickly the wastes disperse from the culture location and the density at which they will accumulate on the seafloor.
- Turbidity in the water - the higher the turbidity the greater the production of pseudo-faeces and faeces by the filter feeding animal and the greater the risk of accumulation on the seafloor.
- Density of culture – suspended mussel culture is considered a dense culture method with high densities of culture organisms over a small area. The greater the density of organisms the greater the risk of accumulations of material. The density of culture organisms is a function of:
    - depth of the site (shallow sites have shorter droppers and hence fewer culture organisms),
    - the husbandry practices proper maintenance will result in optimum densities on the lines in order to give high growth rates as well as reducing the risk of drop-off of culture animals to the seafloor and sufficient distance among the longlines to reduce the risk of cumulative impacts in depositional areas.

In addition placement of structures associated with mussel culture can influence the degree of light penetration to the seabed. This is likely important for organisms and habitats e.g. Maërl and seagrasses which need sun light for production. Rafts or lines will to a degree limit light penetration to the sea bed and may therefore reduce production of photosynthesising species. However, such effects have not been demonstrated for seagrass.

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

- Hydrography – low current speeds (or small tidal range) may result in material being deposited directly beneath the trestles. If tidal height is high and large volumes of water moved through the culture area an acceleration of water flow can occur beneath the trestles and bags, resulting in a scouring effect or erosion and no accumulation of material.
- Turbidity of water – as with suspended mussel culture, oysters have very plastic response to increasing suspended matter in the water column with a consequent increase in faecal or pseudo-faecal production. Oysters can be cultured in estuarine areas (given their polyhaline tolerance) and as a consequence can be exposed to elevated levels of suspended matter. If currents in the vicinity are generally low, elevated suspended matter can result in increase build-up of material beneath culture structures.
- Density of culture – the density of oysters in a bag and consequently the density of bags on a trestle will increase the likelihood of accumulation on the seafloor. In addition, if the trestles are located in close proximity a greater dampening effect can be realised with resultant accumulations. Close proximity may also result in impact on shellfish performance due to competitive interactions for food.
- Exposure of sites - the degree to which the aquaculture sites are exposed to prevailing weather conditions will also dictate the level of accumulated organic material in the area. As fronts move through culture areas increased wave action will resuspend and disperse material away from the trestles.

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

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

Intertidal culture of clam species is typically carried out in the sediment covered with netting to protect the stock from predators. The high density of the culture organisms can lead to exclusion of native biota and the ground preparation and harvest methods (by mechanical means or by hand) can lead to considerable disturbance of biota characterising the habitat.

Sub-tidal shellfish culture i.e. Scallops: This activity involves relaying shellfish on the seabed. There may be increased enrichment due to production of faeces and pseudofaeces in high density cultures. The existing in-faunal community may be changed as a result. Seabed habitat change may also result as a result of dredging during maintenance and harvesting. Uncontained sub-tidal shellfish culture will lead to change in community structure and function through the addition, at high % cover, of an epi-benthic species (living on the seabed) to an infaunal sedimentary community.

The activities associated with this culture practice (dredging of the seabed) are considered disturbing which can lead to removal and/or destruction of infaunal species and changes to sediment composition.

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

Oyster culture poses a risk in terms of the introduction of non-native species as the Pacific oyster (*Crassostrea gigas*) is a non-native species. Recruitment of *C. gigas* has been documented in a number of Bays in Ireland and appears to have become naturalised (i.e. establishment of a breeding population) in two locations (Kochmann et al 2012; 2013) and may compete with the native species for space and food. The culture of large volumes of Pacific oysters may increase the risk of successful reproduction in Kenmare River SAC. The use of triploid (non-reproducing) stock is the main method employed to mange this risk. Furthermore, the introduction of non-native species as 'hitchhikers' on and among culture stock is also considered a risk, the extent of which is dependent upon the duration the stock has spent 'in the wild' outside of Kenmare River. 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 Kenmare Bay, 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/). The manila clam, *Ruditapes philippinarum*, has not been cultured in the bay as yet. No record of this species has been recorded in the wild in Ireland since its introduction in 1984.

Finfish Culture: Within the Kenmare River SAC there are six (5 licensed, 1 application) marine sites assigned for the culture of salmon (and other finfish). Four of these sites are currently active in the production of salmon (*Salmo salar*).

Finfish culture differs from shellfish culture in that there is an input of feed into the system and as a consequence a net input of organic matter to the system. This material will be found in the system in the form of waste feed (on the seafloor), solid waste (faeces), waste as a consequence of net-cleaning all of which usually accumulates on the seafloor and dissolved material (predominantly fractions rich in nitrogen). For the most part, the majority of organic material builds up on the seabed generally in and around the footprint of the salmon cages with a 'halo' effect evident in areas where dispersion occurs driven by local hydrographic conditions. This is typically referred to a *near-field* effects. Similar to shellfish, the quantity of material that might accumulate on the seabed will be a function of the quantity of fish held in cages, the stage of culture, the health of the fish (unhealthy fish will generally eat less), husbandry practices (are the fish fed too much too quickly?), the physical characteristic of the solid particles and, as mentioned above, hydrographic conditions.

Wildish et al. (2004) and Silvert and Cromey (2001) both summarize the factors (listed above) that govern the level of dispersion of material from the cages to the seafloor. Many of the factors are subsequently incorporated into modelling efforts which are used to predict likely levels of impact. The impact of organic matter on sedimentary seafloor habitat typically evolves after the gradient defined by Pearson-Rosenberg (1978), whereby as the level of organic enrichment increases the communities (macrofaunal species number and abundance) found within the sedimentary habitats will also change. Typically, low levels of enrichment facilitates an increase in species abundance and biomass followed by a decrease in all biological metrics as enrichment increases to a point where azoic conditions prevail and no biota are found. The impact on biota is a consequence of the decrease in oxygen and a build-up of by-products such as ammonia and sulphides brought about by the breakdown of the organic particles which are considered toxic to marine biota. The shift from an oxygenating to reducing environment in the sediment could be such that the effect is mirrored in the water column as well (i.e. reduction in oxygen levels). The output of dissolved material resulting from finfish cages is typically in the form of ammonia, phosphorous and dissolved organic carbon (DOC) originating directly from the culture organisms, or from the feed and/or faecal pellets. Similar to particulate waste, the impact of dissolved material is a function of the extent (intensity) of the activity and properties of the receiving environment (e.g., temperature, flushing time). While elevated levels of nutrient have been reported near fish farms, no significant effect on chlorophyll has been demonstrated (Pearson and Black, 2001).

Diseases: It is likely that the first outbreaks of infectious diseases in marine aquaculture operations were caused by pathogens originating in wild hosts and as culture extent and intensity increases the transmission of pathogens (back) to the wild fish stocks is a likely consequence. The result of such pathogen transmission back to wild fish is however unknown, as reports of clinical effects or significant mortality in wild fish populations are largely unavailable. Numerous reviews, models, risk assessments and risk analysis have been carried out or developed in order to determine the potential for disease interaction and pathogen exchange between farmed and wild finfish (OIE 2004, Bricknell *et al*. 2006, DIPNET 2006, Peeler *et al*. 2007). On foot of these outputs there is general acceptance among scientists and managers that pathogens can be transmitted between organisms used in mariculture and those found in the wild and vice-versa (ICES 2013).

The risk of infection in marine organisms, are influenced by a number of environmental factors including temperature, salinity and dissolved oxygen (Grant and Jones 2011), as well as factors particular to the biology of pathogen, e.g., replication rates, virulence. Transmission of pathogens is facilitated by one or a combination of three mechanisms, i.e., horizontal, vertical and vector-borne. Horizontal transmission refers to the direct movement through the water column of a pathogen between susceptible individuals and the open design of most mariculture cages allows the potential for bidirectional transmission of pathogens between wild and captive fish (Johansen *et al.* 2011). Vertical transmission involves the passing of a pathogen with milt or eggs, resulting in infection among offspring. Pathogens can also be spread by a third host or vector. Vectors can include other parasites, fish, piscivorous animals or inanimate objects such as clothing, vessels or equipment.

Disease transmission within culture systems is a primary concern of operators and as a consequence of monitoring and screening, a far greater knowledge base relating to disease causing organisms and their transmission is available relating to cultured stocks rather than wild stocks. As a result of the lack of empirical data relating to diseases specific to wild stocks, it has been difficult to partition population effects in wild-stocks caused by diseases from those caused by other processes (ICES 2010).

Ireland enjoys a high health status (Category 1) in relation to the fish/shellfish on farms, in rivers and lakes and remains free of many diseases that occur in other countries (www.fishhealth.ie). In Ireland, there are programmes in place that govern the movement of (fish and shellfish) stock for on-growing among sites. These movement controls are supported by a risk-based fish health surveillance programme which is operated on a nationwide basis by the Marine Institute, in co-operation with private veterinary practitioners. Ireland is currently free of the following salmonid diseases covered by (Council Directive 2006/88/EC):

- Infectious Salmon Anaemia (ISA)
- Viral Haemorrhagic Septicaemia (VHS)
- Infectious Haematopoetic Necrosis (IHN)
- Gyrodactylosis

Apart from the diseases listed under EU legislation, routine tests are carried out for other diseases found in marine salmonids in Ireland e.g. Pancreas Disease (PD), Infectious Pancreatic Necrosis (IPN), Furunculosis etc. Such diseases are present in Ireland and whilst their control is not covered by legislation, all finfish farmers in the country have agreed to comply with the parameters of a Code of Practice and Fish Health Handbook, jointly agreed between the Marine Institute and the Irish Farmers Association (IFA). These documents cover all aspects of disease prevention and control on Irish fish farms with the twin objectives of minimising disease outbreaks and of dealing with them in a timely and responsible fashion, should they arise. The net outcome should be a decrease in mortality rates on fish farms and a corresponding decrease in potential pathogen transfer to wild stocks. Ensuring the ongoing good health of farmed stocks and the regular monitoring of environmental conditions will also help to minimise the disease impacts which may be caused by infection from wild stocks in the vicinity of the cages.

Disease Management: Council Directive 2006/88/EC on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals form the legislative basis that governs the monitoring and management of disease outbreaks in mariculture operations in Ireland. For diseases not listed in this Directive, a Code of Practice and Fish Health Handbook has been developed jointly by the State and industry with the primary objectives of disease prevention and control.

The adoption of chemotherapeutants and some vaccination programmes have assisted in reducing the abundance and spread of many pathogens. In addition, the principles outlined in the Fish Health Handbook mentioned above such as improved biosecurity practices on farms, fallowing sites to break transmission cycles, disease testing of fish prior to transfer, single year class stocking, coordinating treatments and harvesting within embayments etc have mitigated the transmission of pathogenic organisms.

In summary, it is clear that a number of broad factors govern the transfer of diseases between susceptible organisms. While statistical correlations have been demonstrated in terms of abundance of cultured fish and disease occurrence in wild fishes, extreme caution must apply in terms of applying causality. It is important to note that the only way to determine the link between disease outbreaks in aquaculture installations and detection in wild fish is to empirically measure or observe pathogen transfer. Furthermore, when a risk presents, it not clear if the impact on the wild fish is expressed at the individual and/or population level. While certain effects have been demonstrated at the level of individuals, research has not yet clearly identified or quantified these links at the population level. Disease management programmes operated on a statutory basis by the State and on a voluntary basis by industry *via* Codes of Practice, assist in ensuring that pathogen transfer both to and from farmed fish is kept to a minimum.

Parasites: Sea lice are a group of parasitic copepods found on fish worldwide. There are two species of sea lice commonly found on cultured salmonids in marine conditions around the coast of Ireland, *Caligus elongatus* Nordmann, which infests over eighty different species of marine fish, and *Lepeophtheirus salmonis* Krøyer (the salmon louse), which infests only salmon, trout and closely related salmonid species. *L. salmonis*, the salmon louse, is the more serious parasite on salmon, both in terms of its prevalence and effects. It has been reported as a common ecto-parasite of both wild and farmed salmon at sea.

Returning wild salmon have been found to carry an average of 10 or more adult egg bearing females on their return to the Irish coastline (Copley *et al.,* 2005*;* Jackson *et al.,* 2013a) from their feeding grounds in the Atlantic. Having evolved their relationship with salmon and trout over many millennia, the parasite is well adapted to target its host species and it is ubiquitous to all the coastal waters around Ireland and indeed throughout the range of the Atlantic salmon (Jackson *et al.*, 2013b).

Salmon, whether wild or cultured, go to sea from fresh water free of sea lice and only pick up the infestation after they enter the marine phase of their lives. Sea lice infestations can inflict damage to their hosts through their feeding activity on the outside of the host's body by affecting the integrity of the fish's epithelium, which impairs its osmoregulatory ability and leaves the fish open to secondary infections. In extreme cases this can lead to a reduced growth rate and an increased morbidity in affected individuals.

Marine finfish farms are perceived by certain sectors to be problematic because of the proximity of some operations to river mouths and a concern over the possible impact on wild migratory salmonid fisheries through infestation with sea lice. The studies on the impacts of lice infestation on smolts (Jackson *et al.* 2011, 2013a) suggest that sea lice induced mortality on outwardly migrating smolts is likely a minor and irregular component of marine mortality in the stocks studied. This conclusion is further supported by the finding of no correlation between the presence of aquaculture and the performance of adjacent wild salmon stocks.

Parasite Management: Based on the evidence from targeted studies, the information collected as part of the National Sea Lice Monitoring and Control Programme, scientific reports published by the Marine Institute, and in-line with external advice, it is concluded that there is a robust and effective management programme in place in Ireland to control sea lice infestation on farmed fish. Furthermore, there is no empirical evidence to support the suggestion that the fisheries are being adversely affected by unusual levels of sea lice infestation, whether of farmed origin or from other sources.

Table 4: Potential indicative environmental pressures of aquaculture activities within the qualifying interests (Large shallow inlets and bays (1160), Reefs (1170) and Submerged or partially submerged seacaves (8330)) of the Kenmare River SAC.

Activity	Pressure category	Pressure	Potential effects	Equipment	Duration (days)	Time of year	Factors constraining the activity
Aquaculture							
Rope Mussel and other suspended culture methods	Physical	Current alteration	Baffling effect resulting in a slowing of currents and increasing deposition onto seabed changing sedimentary composition	Floats, longlines, continuous ropes (New Zealand system) and droppers	365	All year	Location (sheltered location for year round activity)
	Biological	Organic enrichment	Faecal and pseudofaecal deposition on seabed potentially altering community composition. Drop-off of culture species.				
		Shading	Prevention of light penetration to seabed potentially impacting light sensitive species				
		Fouling	Increased secondary production on structures and culture species. Increased nekton production				
		Seston filtration	Alteration of phytoplankton and zooplankton communities and potential impact on carrying capacity				
		Nutrient exchange	Changes in ammonium and Dissolved inorganic nitrogen				

Activity	Pressure category	Pressure	Potential effects	Equipment	Duration (days)	Time of year	Factors constraining the activity
			resulting in increased primary production. Nitrogen (N_2) removal at harvest.				
		Alien species	Introduction of non-native species with culture organism transported into the site				
Intertidal Oyster Culture	Physical	Current alteration	Structures may alter the current regime and resulting increased deposition of fines or scouring.	Trestles and bags and service equipment	365	All year	At low tide only
		Surface disturbance	Ancillary activities at sites, e.g. servicing, transport increase the risk of sediment compaction resulting in sediment changes and associated community changes.				
		Shading	Prevention of light penetration to seabed potentially impacting light sensitive species				
	Biological	Non-native species introduction	Potential for non-native species (*C. gigas*) to reproduce and proliferate in SAC. Potential for alien species to be included with culture stock (hitch-hikers).				
		Disease risk	In event of epizootic the ability to manage disease in uncontained subtidal oyster				

Activity	Pressure category	Pressure	Potential effects	Equipment	Duration (days)	Time of year	Factors constraining the activity
			populations is compromised.				
		Organic enrichment	Faecal and pseudofaecal deposition on seabed potentially altering community composition				
Subtidal Shellfish culture	Physical	Surface disturbance	Abrasion at the sediment surface and redistribution of sediment	Dredge	Once quarterly	Seasonal	Weather for site access. Size of shellfish and market constraints
		Shallow disturbance	Sub-surface disturbance to 25mm				
	Biological	Monoculture	Habitat dominated by single species and transformation of infaunal dominated community to epifaunal dominated community.				
		By-catch mortality	Mortality of organisms captured or disturbed during the harvest or process, damage to structural fauna of reefs				
		Non-native species introduction	Potential for alien species to be included with culture stock (hitch-hikers)				
		Disease risk	In event of epizootic the ability to manage disease in uncontained subtidal shellfish populations would likely be compromised. The risk				

Activity	Pressure category	Pressure	Potential effects	Equipment	Duration (days)	Time of year	Factors constraining the activity
			introduction of disease causing organisms by introducing seed originating from the 'wild' in other jurisdictions				
		Nutrient exchange	Increased primary production. N_2 removal at harvest or denitrification at sediment surface.				
Salmon	Biological	Nutrient exchange	Increased primary production. N_2 removal at harvest or denitrification at sediment surface.		365		Fallow periods when no fish in the cages in the water.
		Organic enrichment	Faecal and waste food on seabed potentially altering community composition		365		
		Disease risk	Transmission of diseases and parasites between culture organisms and wild stocks and vice-versa.		365		
		Shading	Prevention of light penetration to seabed potentially impacting light sensitive species	Cages	365		Fallow periods when no fish in the cages in the water. Netting generally removed.

Aquaculture and Harbour Seal Interactions: In relation to Harbour seals (*Phoca vitulina*), less information is available on the potential interactions between the species and the activities in question (see NRC 2009). There has been no targeted research conducted in similar ecosystems that has directly assessed the impact of this type of aquaculture on harbor seals or indeed any other seal populations. There has, however, been considerable research on short-term responses of harbor seals to disturbance from other sources, and these can be used to inform assessments the potential impacts of disturbance from aquaculture activities currently underway and proposed in Kenmare River SAC. These disturbance studies have focused on impacts upon groups of seals that are already ashore at haul-out sites. Sources of potential disturbance have varied widely, and include people and dogs (Allen *et al.*, 1984; Brasseur & Fedak, 2003), recreational boaters (Johnson & Acevedo-Gutierrez, 2007; Lelli & Harris, 2001; Lewis & Mathews, 2000), commercial shipping (Jansen et al., 2006), industrial activity (Seuront & Prinzivalli, 2005) and aircraft (Perry et al., 2002). A harbor seal's response to disturbance may vary from an increase in alertness, movement towards the water, to actual entering into the water, i.e. flushing (Allen et al., 1984) and is typically governed by the location and nature of the disturbance activity. For example, kayaks may elicit a stronger response than power boats (Lewis & Mathews, 2000; Suryan & Harvey, 1999), and stationary boats have been shown to elicit a stronger response than boats moving along a predictable route (Johnson & Acevedo-Gutierrez, 2007). Furthermore, the mean distance at which seals are flushed into the water by small boats and people ranges between 80m and 530m, with some disturbances recorded at distances of over 1000m. In certain areas, these empirical studies have been used to inform management actions in marine protected areas, for example where a 1.5km buffer is set around harbor seal haul-out sites in the Dutch Wadden Sea to exclude recreational disturbance (Brasseur & Fedak, 2003).

Displacement from areas may also result from disturbances attributable to the activities of mariculture workers (Becker et al., 2009; 2011). This disturbance may be caused directly by the presence of workers on intertidal areas. However while disturbance from shellfish culture operations have been observed to influence the distribution of seal within a sheltered embayment, no inference was made on the effect on broader population characteristics of harbour seals from this study (Becker 2011).

Potential interactions between shellfish culture and marine mammals are broadly summarized in Table 5. It should be noted that direct demonstrations of these impacts are rare, and in most cases, potential effects are therefore predicted from the best existing information (NRC, 2010). Furthermore, none of the studies published to explore impacts on marine mammals and in particular Harbour Seals, were specifically designed to detect ecological impacts on this species (NRC 2009; Becker *et al*., 2009, 2011). Even where studies have been carried out around shellfish farms, uncertainty over spatial and temporal variation in both the location of structures (Watson-Capps and Mann, 2005) and levels of disturbance (Becker *et al*., 2009; 2011) constrain the conclusions that can be drawn about the impacts of mariculture on critical life functions such as reproduction and foraging.

Mariculture operations are considered a source of marine litter (Johnson, 2008). Ingestion of marine litter has also been shown to cause mortality in birds, marine mammals, and marine turtles (Derraik, 2002).

Mariculture structures can provide shelter, roost, or haul-out sites for birds and seals (Roycroft *et al*., 2004). This is unlikely to have negative effects on bird or seal populations, but it may increase the likelihood that these species cause faecal contamination of mollusc beds.

Seal interactions with marine finfish cages have been described (Aquaculture Stewardship Council, 2012). The seals (as predators) are attracted to the structures and their contents and have been known to tear netting in attempts to acquire prey items (i.e. cultured finfish). While a risk of entanglement in netting may present, it is not considered likely and the greatest risk is the escape of stocked fishes. In order to mitigate this risk, operators have resorted to the use of deterrent devices (Acoustic or Harassment) which have variable results based upon the location, extent of use and mammals targeted. However, deterrent devices are now considered detrimental to seals and alternative management actions are advised (Nelson 2004; Aquaculture Stewardship Council 2012). Therefore, careful stock management (density control and regular removal of mortalities from cages), use of seal blinds and appropriate net tensioning are all considered suitable methods to minimise negative interactions between seals and finfish culture. Lethal actions to remove seals are only allowed under licence, the criteria which are determined by NPWS (Section 42 of the Wildlife Act, 1976 (as amended).

The Kenmare River is deemed important both on a regional and on a national scale regarding its Harbour Seal population. The overall Harbour Seal numbers (population) has been stable or increasing between 2003 and 2012 (NPWS data) coincident with static levels of mariculture production. While no definitive conclusions can be drawn regarding the population status of harbour seals in the Kenmare River and more widely around Ireland, based upon survey reports from 2009-2011 (as no baseline reference values are provided), it would appear that the levels both regionally and nationally are stable or possibly increasing (see Figure 2 in NPWS 2012).

6.2 Fisheries

Fisheries using bottom contacting mobile gears cause physical abrasion and disturbance pressure to marine habitats in Kenmare River. These include bottom trawling on sedimentary habitats and dredging in mixed sediments and at the edge of reef for scallop. Pot fisheries and static net fisheries may cause localized abrasion and disturbance to habitats which may be significant for habitats that are highly sensitive to such pressures. All fisheries extract fish biomass which may reduce habitat quality for designated species such as otter and harbour seals. Harbour seals and otters may be caught as by-catch in certain gears such as pelagic trawls and trammel nets set for bait in shallow water.

6.3 In-combination activities

Other activities leading to potential impacts on conservation features relate to harvest of seaweed on intertidal reef communities. There is little known concerning the level of harvest from these intertidal reef communities. The impact is likely two-fold, direct impact upon the reefs by removal of a constituent species and impact upon intertidal sediments as a consequence of travel across the shore to the harvest sites.

Seal watching cruises are conducted in Kenmare. Given the nature of this activity it is unlikely that they will result in extensive disturbance to seal species.

There are a number of activities which are terrestrial in origin that might result in impacts on the conservation features of the Kenmare River SAC. Primary among these are point source discharges from municipal and industrial units (Shellfish Pollution Reduction Programme, DECLG). There are five urban waste water treatment plants in the general vicinity of the SAC. These are found in Ardgroom, Kenmare, Sneem, Kilgarvan, Eyeries. The pressure derived from these facilities is a discharge that may impact upon levels of dissolved nutrients, suspended solids and some elemental components e.g. aluminium in the case of water treatment facilities.

Table 5: Potential interactions between aquaculture activities and the Annex II species Harbour Seal (*Phoca vitulina*) within the Kenmare River SAC.

Culture Method	Pressure category	Pressure	Potential effects	Equipment	Duration (days)	Time of year	Factors constraining the activity
All Aquaculture Methods	Physical	Habitat Exclusion	Structures may result in a barrier to movement of seals.	Net pens, Bags and trestles	365	All year	Spatial extent and location of structures used for culture.
		Disturbance	Ancillary activities at sites increase the risk of disturbance to seals at haul out sites (resting, breeding and/or moulting) or in the water.	Site services, human, boat and vehicular traffic	365	All year	Seasonal levels of activity relating to seeding, grading, and harvesting. Peak activities do no coincide with more sensitive periods for seals (i.e. pupping and moulting)
		Entanglement	Entanglement of seals from ropes or material used on structures or during operation of farms	Trestles, bags, ropes and/or nets used in day to day	365	All year	Farm management practices
		Ingestion	Ingestion of waste material used on farm	Ties used to secure bags and secure bags to trestle	365	All year	Farm management practices
		Deterrent Methods	Seals interfering with cages will result in deterrent actions, e.g. use of Acoustic deterrent or harassment Devices. If all non lethal avenues fail then lethal methods may be employed (under licence).	ADDs and lethal devices (shooting)	365		Fallow periods no fish on-site

Table 6: Potential pressures caused by fisheries in the Kenmare River SAC.

METIER/ ACTIVITY	PRESSURE CATEGORY	PRESSURE	POTENTIAL EFFECTS	FISHING GEARS OR AQUACULTURE EQUIPMENT	DURATION (DAYS)	TIME OF YEAR	FACTORS CONSTRAINING THE ACTIVITY
Potting,for shrimps	Physical	Surface disturbance	Abrasion at the sediment surface	Shrimp pots	240	August to March	catch rate, weather, market
	Biological	Extraction	Removal of shrimp				
		By-catch	Mortality of species in by-catch				
Lobster and crab potting	Physical	Surface disturbance	Abrasion at the sediment surface	Soft eye side entrance creels and top entrance pots	Approx 240	Mainly March to October	catch rate, weather, market
	Biological	Extraction	Removal of lobster and crab				
		By-catch	Mortality of species in by-catch				
Tangle netting	Physical	Surface disturbance	Abrasion at the sediment surface	Tangle nets	Unknown	Mainly May to Sept	catch rate, weather,
	Biological	Extraction	Removal of crayfish and other commercial fish species				
		By-catch	Potential by-catch of designated species grey seal, porpoise and otter.				

METIER/ ACTIVITY	PRESSURE CATEGORY	PRESSURE	POTENTIAL EFFECTS	FISHING GEARS OR AQUACULTURE EQUIPMENT	DURATION (DAYS)	TIME OF YEAR	FACTORS CONSTRAINING THE ACTIVITY
Dredging for scallops	Physical	Surface disturbance	Abrasion at the sediment surface	Fixed toothed dredges (DRB), ICES code 04.1.1	unknown	Mainly winter and spring	catch rate, weather, market, spatial closures
		Shallow disturbance	Sub-surface disturbance to 25mm				
	Biological	Extraction	Removal of scallops				
		By-catch mortality	Mortality of organisms captured or disturbed during the fishing process, damage to structural fauna of reefs				
Midwater (pelagic) trawling	Biological	Extraction	Removal of pelagic fish (Herring and sprat)	Pelagic trawls, OTM, ICES 03.2.1.	Unknown	Sept to March	Fish biomass
		By-catch	Potential by-catch of designated species harbour seal and otter.				
Hook and line pelagic	Biological	Extraction	Removal of pelagic and demersal fish	Hooks and lines, LHP, ICES 09.1.0, LHM, ICES 09.2.0, LTL, ICES 09.6.0	Unknown	Summer, Autumn	Quota, weather
Bottom set tangle nets	Physical	Surface disturbance	Abrasion at the sediment surface	Gill nets, GNS, ICES 07.1.0	Unknown	All year	weather

METIER/ ACTIVITY	PRESSURE CATEGORY	PRESSURE	POTENTIAL EFFECTS	FISHING GEARS OR AQUACULTURE EQUIPMENT	DURATION (DAYS)	TIME OF YEAR	FACTORS CONSTRAINING THE ACTIVITY
	Biological	Extraction	Removal of demersal fish				
		By-catch	Potential by-catch of designated species harbour seal and otter.				
Mixed fisheries demersal trawling	Physical	Surface disturbance	Abrasion at the sediment surface	Demersal single bottom otter trawls (OTB, ICES code 03.1.2	Unknown	All year	Weather, quota restrictions
		Shallow disturbance	Sub-surface abrasion by trawl doors				
	Biological	Extraction	Removal of fish				
		By-catch mortality	Mortality of organisms in contact with fishing gear				
Trammel nets (bait fishery)	Physical	Surface disturbance	Abrasion on sediment surface or on reefs	GTR, ICES 07.5.0	Unknown	All year	Availability and price of bait
	Biological	Extraction	Removal of non-commercial fish species				
		By catch	Potential catch of designated species otter and harbour seal				

7. Screening of Aquaculture Activities

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

In this assessment screening of the qualifying interests against the proposed activities is based primarily on spatial overlap i.e. if the qualifying interests overlap spatially with the proposed activities then significant impacts due to these activities on the conservation objectives for the qualifying interests is not discounted (not screened out) except where there is absolute and clear rationale for doing so. Where there is relevant spatial overlap full assessment is warranted. Likewise if there is no spatial overlap and no obvious interaction is likely to occur, then the possibility of significant impact is discounted and further assessment of possible effects is deemed not to be necessary. Table 2 provides spatial overlap extent between designated habitat features and aquaculture activities within the qualifying interests of the Kenmare River SAC.

7.1 Aquaculture Activity Screening

- The marine habitat Submerged or Partially Submerged Seacaves (8330) has no spatial overlap with (existing and proposed) aquaculture activities.
- Table 2 highlights the spatial overlap between (existing and proposed) aquaculture activities and both habitat features (i.e. Large Shallow Inlet and Bay and Reefs).
- Tables 6 and 7 provide an overview of overlap of aquaculture activities and specific community types (identified from Conservation Objectives) within the broad habitat features 1160 and 1170, respectively.

Where the overlap between an aquaculture activity and a feature is zero it is screened out and not considered further. Therefore, the feature **Submerged or partially submerged sea caves (8330)** is excluded from further consideration in this assessment.

Furthermore, if the aquaculture activity occurs within the SAC but does not overlap a keystone community[8] habitat type or overlap with a feature of interest then they are excluded from further assessment.

Therefore, the following habitats and one species are also excluded from further consideration in this assessment:

- **1014 Marsh Snail *Vertigo angustior***
- **1303 Lesser Horseshoe Bat *Rhinolophus hipposideros***

[8] NPWS 2013. Kenmare River SAC (site code: 2158)-Conservation objectives supporting document - Marine habitats and species. Version 1 March 2013

- **1220 Perennial vegetation of stony banks**
- **1230 Vegetated sea cliffs of the Atlantic and Baltic coasts**
- **1330 Atlantic salt meadows (Glauco-Puccinellietalia maritimae)**
- **1410 Mediterranean salt meadows (*Juncetalia maritimi*)**
- **2120 Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes")**
- **2130 Fixed coastal dunes with herbaceous vegetation (grey dunes)**
- **4030 European dry heaths**
- **6130 Calaminarian grasslands of the *Violetalia calaminariae***

Furthermore, of the 11 community types (see Table 1) listed under the two habitat features (1160 and 1170), two (**Intertidal Mobile Sand Community Complex and Shingle**) have no spatial overlap between them and any aquaculture activities. In one instance, the community type **Shingle** appears to overlap with subtidal scallop aquaculture; however, this is considered a mapping anomaly and therefore, the spatial overlap is concluded as nil. On this basis, the community types, **Intertidal Mobile Sand Community Complex** and **Shingle** are excluded from further analysis of aquaculture interactions.

A number of aquaculture operations and applications within **Ardgroom Harbour and Killmackillogue Harbour** that do not overlap with features of interest and/or keystone communities are excluded from further analysis and are considered not to have a significant impact on habitat conservation features.

When overlap was observed it was quantified in a GIS application and presented on the basis of coverage of specific activity (representing different pressure types), licence status (licenced or application) intersecting with designated conservation features and/or sub-features (community types).

Table 6: Habitat utilisation i.e. spatial overlap in hectares and percentage (given in parentheses) of aquaculture activity over relevant community types within the qualifying interest 1160 - Large shallow inlets and bays (Spatial data based on licence database provided by DAFM. Habitat data provided in NPWS 2013a. 2013b).

			1160 – Large shallow inlets and bays								
Culture Type	Location	Status	Coarse sediment dominated by polychaetes comm. Complex 8,314ha	Fine to medium sand with crustaceans and polychaetes comm. Complex 1,989ha	Intertidal reef comm. Complex 526ha	*Laminaria* dominated comm. Complex 3,358ha	Muddy fine sands dominated by polychaetes and *Amphiura filiformis* comm. Complex 20,150ha	Subtidal reef with echinoderms and faunal turf comm. Complex 4,808ha	*P. multiplicatus* Comm. Complex 6ha	Maerl 47ha	*Zostera* *20ha*
Mussel (*Mytilus edulis*) on ropes	Subtidal	L	17.53 (0.2)	8.08 (0.4)	0.03 (5.05E-03)	13.44 (0.4)	4.29 (0.02)	3.61 (0.08)	-	-	-
Mussel (*Mytilus edulis*) on ropes	Subtidal	A	255.88 (3.1)	45.02 (2.36)	-	31.97 (0.95)	57.82 (0.29)	92.79 (1.93)	-	-	-
Scallops (*Pecten maximus*) on seabed	Subtidal	L	37.85 (0.46)	20.15 (1.01)	0.78 (0.15)	199.15 (5.93)	186.21 (0.92)	9.15 (0.19)	6.23 (100.00)	13.06 (27.89)	0.50 (2.52)
Scallops (*Pecten maximus*) on seabed	Subtidal	A	0.47 (0.01)	-	-	1.39 (0.04)	-	-	-	-	-
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	L	-	-	0.80 (0.15)	0.71 (0.02)	5.99 (0.03)	0.03 (5.88E-04)	-	-	-
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	A	-	4.15 (0.21)	0.37 (0.07)	15.47 (0.46)	22.9 (0.11)	1.66 (0.03)	-	-	3.61 (18.05)
Salmon (*Salmo salar*) in net pens	Subtidal	L	46.28 (0.56)	4.31 (0.22)	-	5.45 (0.16)	-	6.62 (0.14)	-	-	-
Salmon (*Salmo salar*) in net pens	Subtidal	A	-	1.68 (0.08)	-	4.63 (0.14)	15.66 (0.08)	9.92 (0.21)	-	-	-
Totals			**358.01 (4.31)**	**83.39 (4.19)**	**1.98 (0.38)**	**272.75 (8.1)**	**292.87 (1.45)**	**123.78 (2.57)**	**6.23 (100.00)**	**13.06 (27.89)**	**4.11 (20.55)**

Table 7: Habitat utilisation i.e. spatial overlap in hectares and percentage (given in parentheses) of Aquaculture activity over relevant community types within the qualifying interest 1170 - Reefs (Spatial data based on licence database provided by DAFM. Habitat data provided in NPWS 2013a, 2013b).

			1170 - Reefs		
Culture Type	**Location**	**Status**	**Intertidal reef community complex** **681ha**	***Laminaria* - dominated community complex** **3678ha**	**Subtidal reef with echinoderms and faunal turf community complex** **4838ha**
Mussel (*Mytilus edulis*) on ropes	Subtidal	L	-	37.74 (1.02)	3.59 (0.07)
Mussel (*Mytilus edulis*) on ropes	Subtidal	A	-	35.92 (0.97)	98.34 (2.03)
Scallops (*Pecten maximus*) on seabed	Subtidal	L	0.78 (0.11)	198.93 (5.41)	9.13 (0.19)
Scallops (*Pecten maximus*) on seabed	Subtidal	A	-	1.82 (0.05)	-
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	L	0.80 (0.12)	0.71 (0.02)	-
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	A	2.94 (0.43)	18.59 (0.51)	1.66 (0.03)
Salmon (*Salmo salar*) in net pens	Subtidal	L	0	5.47 (0.15)	6.61 (0.14)
Salmon (*Salmo salar*) in net pens	Subtidal	A	0	4.62 (0.13)	9.91 (0.21)
			4.52 (0.66)	**303.8 (8.26)**	**129.24 (2.67)**

8. Assessment of Aquaculture Activities

8.1 Determining significance

The significance of the possible effects of the proposed activities on habitats, as outlined in the Natura Impact Statement (Section 6) and subsequent screening exercise (Section 7), is determined here in the assessment. The significance of effects is determined on the basis of Conservation Objective guidance for constituent habitats and species (Figures 1, 2 and NPWS 2013a, 2013b).

Within the Kenmare River SAC the qualifying habitats/species considered subject to potential disturbance and therefore, carried further in this assessment are:

- 1160 Large shallow inlets and bays
- 1170 Reefs
- 1355 Otter - *Lutra lutra*
- 1365 Common (Harbour) seal - *Phoca vitulina*

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

- *Zostera* –dominated community
- Maerl – dominated community
- *Pachycerianthus multiplicatus* community

For broad habitats and community types (Figures 1 and 2) significance of impact is determined in relation to, first and foremost, spatial overlap (see Section 7; Tables 6 and 7). Subsequent disturbance and the persistence of disturbance are considered as follows:

1. <u>The degree to which the activity will disturb the qualifying interest.</u> By disturb is meant change in the characterising species, as listed in the Conservation Objective guidance (NPWS 2013b) for constituent communities. The likelihood of change depends on the sensitivity of the characterising species to the activities in question. Sensitivity results from a combination of intolerance to the activity and/or recoverability from the effects of the activity (see Section 8.2 below).

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

3. <u>The area of communities or proportion of populations disturbed.</u> In the case of community disturbance (continuous or ongoing) of more than 15% of the community area it is deemed

to be significant. This threshold does not apply to sensitive habitats as listed above (*Zostera*, Maerl) where any spatial overlap of activities should generally be avoided.

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

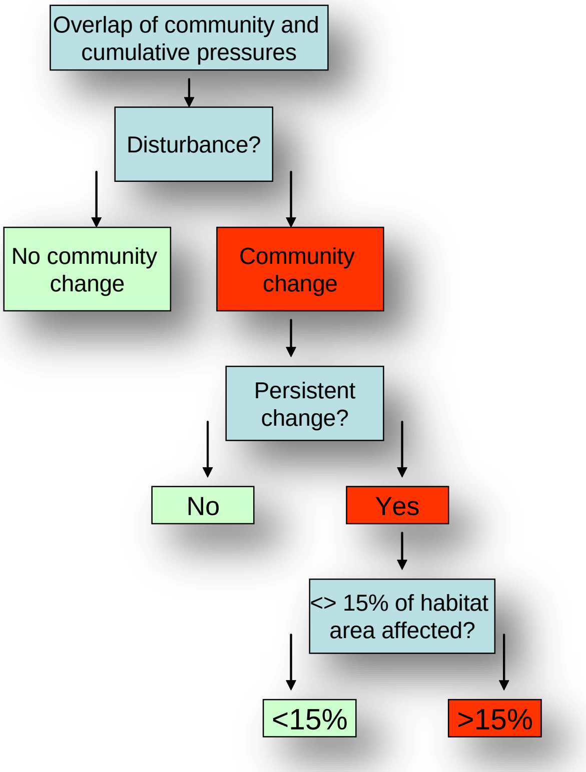

Figure 11: Determination of significant effects on community distribution, structure and function for sedimentary habitats (following NPWS 2013b).

In relation to designated species (Harbour Seal, Otter) the capacity of the population to maintain itself in the face of anthropogenic induced disturbance or mortality at the site will need to be taken into account in relation to the Conservation Objectives (CO's) on a case by case basis.

8.2 Sensitivity and Assessment Rationale

This assessment used a number of sources of information in assessing the sensitivity of the characterising species of each community recorded within the habitat features of the Kenmare River SAC. One source of information is a series of commissioned reviews by the Marine Institute which identify habitat and species sensitivity to a range of pressures likely to result from aquaculture and fishery activities (ABPMer 2013a-h). These reviews draw from the broader literature, including the MarLIN Sensitivity Assessment (Marlin.ac.uk) and the AMBI Sensitivity Scale (Borja et al., 2000) and other primary literature. It must be noted that NPWS have acknowledged that given the wide range of community types that can be found in marine environments, they application of conservation targets to these would be difficult (NPWS 2013b). On this basis, they have proposed broad community complexes as management units. These complexes (for the most part) are very broad in their description and do not have clear surrogates which might have been considered in targeted studies and thus reported in the scientific literature. On this basis, the confidence assigned to likely interactions of the community types with anthropogenic activities are by necessity relatively low, with the exception of community types dominated by sensitive taxa, e.g. Mearl and *Zostera*. Other literature cited in the assessment does provide a greater degree of confidence in the conclusions. For example, the output of a recent study has provided greater confidence in terms of assessing likely interactions between intertidal oyster culture and community types (Forde et al submitted). Sensitivity of a species to a given pressure is the product of the intolerance (the susceptibility of the species to damage, or death, from an external factor) of the species to the particular pressure and the time taken for its subsequent recovery (recoverability is the ability to return to a state close to that which existed before the activity or event caused change). Life history and biological traits are important determinants of sensitivity of species to pressures from aquaculture.

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

- For persistent pressures i.e. activities that occur frequently and throughout the year recovery capacity may be of little relevance except for species/communities that may have extremely rapid (days/weeks) recovery capacity or whose populations can reproduce and recruit in balance with population damage caused by aquaculture. In all but these cases and if sensitivity is moderate or high then the species/habitats may be negatively affected and will exist in a modified state. Such interactions between aquaculture and species/habitat/community represent persistent disturbance. They become significantly disturbing if more than 15% of the community is thus exposed (NPWS 2013a).
- In the case of episodic pressures i.e. activities that are seasonal or discrete in time both the intolerance and recovery components of sensitivity are relevant. If sensitivity is high but recoverability is also high relative to the frequency of application of the pressure then the species/habitat/community will be in favourable conservation status for at least a proportion of time.

The sensitivities of the community types (or surrogates) found within the Kenmare River SAC to pressures similar to those caused by aquaculture (e.g. smothering, organic enrichment and physical disturbance) are identified in Table 8. The sensitivities of species which are characteristic (as listed in the Conservation Objective supporting document) of benthic communities to pressures similar to those caused by aquaculture (e.g. smothering, organic enrichment and physical disturbance) are identified, where available, in Table 9. The following guidelines broadly underpin the analysis and conclusions of the species and habitat/community type sensitivity assessment:

- Sensitivity of certain taxonomic groups such as emergent sessile epifauna to physical pressures is expected to be generally high or moderate because of their form and structure (Roberts *et al.* 2010). Also high for those with large bodies and with fragile shells/structures, but low for those with smaller body size. Body size (Bergman and van Santbrink 2000) and fragility are regarded as indicative of a high intolerance to physical abrasion caused by fishing gears (i.e. dredges). However, even species with a high intolerance may not be sensitive to the disturbance if their recovery is rapid once the pressure has ceased.
- Sensitivity of certain taxonomic groups to increased sedimentation is expected to be low for species which live within the sediment, deposit and suspension feeders; and high for those sensitive to clogging of respiratory or feeding apparatus by silt or fine material.
- Recoverability of species depends on biological traits (Tillin *et al.* 2006) such as reproductive capacity, recruitment rates and generation times. Species with high reproductive capacity, short generation times, high mobility or dispersal capacity may maintain their populations even when faced with persistent pressures; but such environments may become dominated by these (r-selected) species. Slow recovery is correlated with slow growth rates, low fecundity, low and/or irregular recruitment, limited dispersal capacity and long generation times. Recoverability, as listed by MarLIN, assumes that the impacting factor has been removed or stopped and the community type returned to a state capable of supporting the species or community in question. The recovery process is complex and therefore the recovery of one species does not signify that the associated biomass and functioning of the full ecosystem has recovered (Anand & Desrocher, 2004) cited in Hall *et al*., 2008).,

8.3 Assessment of the effects of aquaculture production on the Conservation Objectives for habitat features in the Kenmare River SAC.

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

The constituent communities identified in the Annex 1 feature, **Large Shallow Inlets and Bays (1160)**) are:

1. Intertidal mobile sand community complex (No overlap with aquaculture)
2. *Zostera*-dominated community
3. Maerl-dominated community
4. *Pachycerianthus multiplicatus* community
5. Muddy fine sands dominated by polychaetes and *Amphiura filiformis* community complex
6. Fine to medium sand with crustaceans and polychaetes community complex
7. Coarse sediment dominated by polychaetes community complex

8. Shingle (No overlap with aquaculture)
9. Intertidal reef community complex
10. *Laminaria*-dominated community complex
11. Subtidal reef with echinoderms and faunal turf community complex

For Large Shallow Inlets and Bays (1160) there are a number of attributes (with associated targets) relating to this habitat feature as well as its constituent community types;

1. **Habitat Area** – it is unlikely that the activities proposed will reduce the overall extent of permanent habitat within the feature Large Shallow Inlet and Bays. The habitat area is likely to remain stable.
2. **Community Distribution - (conserve a range of community types in a natural condition).**

   This attribute considered interactions with 8 of the community types listed above and exclude three sensitive communities (i.e., *Zostera*-dominated community, Maerl-dominated community and *Pachycerianthus multiplicatus* community). Of the 8 communities, 2 have no overlap with aquaculture activities. Therefore, the following 6 community types, found within the qualifying interest 1160 of the SAC have overlap with aquaculture activities:

   1. Muddy fine sands dominated by polychaetes and *Amphiura filiformis* community complex
   2. Fine to medium sand with crustaceans and polychaetes community complex
   3. Coarse sediment dominated by polychaetes community complex
   4. Intertidal reef community complex
   5. *Laminaria*-dominated community complex
   6. Subtidal reef with echinoderms and faunal turf community complex

   The community types listed above will be exposed to differing ranges of pressures from aquaculture activities. Some of these may result in more chronic and long term changes in community composition which were considered during the assessment process. Such activities in dredging for scallop which will result in physical disturbance to infanal communities and longline mussel culture and finfish farming which results in organic loading on the seabed resulting in biogeochemical changes to sediment and a likely change in faunal compositions – whether this results in permanent change to the community type is unclear. Table 8, where possible, lists the community types (or surrogates) and Table 9 lists the constituent taxa and both provide a commentary of sensitivity to a range of pressures. The risk scores in Table 8 and 9 are derived from a range of sources identified above. The pressures are listed as those likely to result from the primary aquaculture activities carried out in the Kenmare River SAC. Aquaculture activities in the Kenmare River SAC comprises of both finfish and shellfish production. Considered in the assessment are intertidal oyster culture (bag and trestle), subtidal scallop on-bottom culture, intertidal clam on-bottom culture, subtidal (suspended) rope mussel culture, and Atlantic salmon culture in net pens.

Table 11 below identify the likely interactions between the relevant aquaculture activities and the broad habitat feature (1160) and their constituent community types, with a broad conclusion and justification on whether the activity is considered disturbing to the feature in question. It must be noted that the sequence of distinguishing disturbance is as highlighted above, whereby activities with spatial overlap on habitat features are assessed further for their ability to cause persistence disturbance on the habitat. If persistent disturbance is likely then the spatial extent of the overlap is considered further. If the proportion of the overlap exceeds a threshold of 15% disturbance of the habitat (or each constituent community type) then any further licencing should be informed by interdepartmental review and consultation (NPWS 2013b). While some activities (e.g. suspended mussel culture, intertidal clam culture and salmon cage culture) might result in long-term change to the 6 community types identified above; in all cases, no activity (individually or combined) extends beyond 15% of the community type (Tables 6 and 11). In addition, combined activities listed overlap with 2.88% of habitat feature (1160) Large Shallow Inlet and Bay (Table 3). On the basis of targeted research (Forde et al, Submitted) and the fact that intertidal oyster culture on trestles is considered non-disturbing to both sedimentary communities and intertidal reef communities, further assessment (i.e. spatial analysis) is not required.

3. **Community Extent and Structure – focusing upon Mearl, *Zostera* and *Pachycerianthus multiplicatus* communities**

The focus of these attributes are primarily upon the 3 community types, *Zostera*-dominated community, Maerl-dominated community and *Pachycerianthus multiplicatus* community. These communities are considered highly diverse and sensitive community types which host a wide range of taxa. The 'keystone' species in each community type (Maerl and *Zostera*) is considered important and sensitive in their own right. It should be noted that maerl beds exist within Ardgroom and Killmakilloge Harbours, which are not within the qualifying interest (i.e. 1160 Large shallow inlets and bays or 1170 Reefs). However, as these maerl beds are still within the SAC boundary and are listed in Annex V of the Habitats Directive they must be afforded protection and maintained in favourable conservation status.

The Kenmare River is one of a very small number of sites within Europe where the large tube building anthozoan *Pachycerianthus multiplicatus* is known to occur. This community is found in coarse sediment dominated by a polychaete community complex. The anthozoan itself resides in a large tube which is known to provide a variety of micro niches thus resulting in localised increases in biodiversity. *P. multiplicatus* is listed in the UK Biodiversity Action Plan as a species of conservation concern (Biodiversity Steering Group, 1995). According to (Wilding & Wilson, 2009) the species is deemed nationally rare, and due to its limited, fragmented distribution, populations are likely to be of global importance.

Given the highly sensitive natures of these community types and constituent taxa (Table 8 and 9) it is highly likely that aquaculture activities of any type which overlap these community type and the pressures may result in long-term or permanent change to the extent of these community types and the impact upon their structure and function cannot be discounted. This effect will come about by the physical removal or damage caused by the activities on any of the highly diverse taxa associated with these community types (Table 11). In addition, the impact of the placement of large numbers of scallop seed on seagrass beds and subsequent harvest by scuba diving is uncertain, in the absence of information on the nature of the diving operation (exact method of extraction).

The constituent communities identified in the Annex 1 feature **Reefs (1170)** are:

1. Intertidal reef community complex
2. *Laminaria*-dominated community complex
3. Subtidal reef with echinoderms and faunal turf community complex

Similar to Large Shallow Inlets and Bays (1160) there are a number of attributes (with associated targets) relating to Reef (1170) habitat features as well as associated constituent community types;

1. **Distribution and Habitat area:** The aquaculture activities in question will not, by virtue of the pressures associated with them, impact on the broad distribution of reef structures and reduce the area of these features within the SAC.
2. **Community Structure:** The intertidal reef community, which is extensive within the SAC, is dominated by brown algal species with red algae and a faunal aspect typical of the rocky intertidal (i.e. gastropods, anemones and sponges). The subtidal rocky communities are dominated by large macro algae (kelp) and faunal turf (anthozoans, echinoderms, hydrozoans and sponges).

   Table 8 lists the community (or surrogates) and Table 9 lists the constituent taxa and both provide a commentary of sensitivity to a range of pressures. The risk scores are derived from a range of sources identified above. The pressures are listed as those likely to result from the primary aquaculture activities carried out in the Kenmare River SAC. Aquaculture activities in the Kenmare River SAC comprises of both finfish and shellfish production. Considered in the assessment are intertidal oyster culture (bag and trestle), subtidal scallop on-bottom culture, intertidal clam on-bottom culture, subtidal (suspended) rope mussel culture, and Atlantic salmon culture in net pens.

   Suspended culture activities of finfish and rope mussel can lead to organic enrichment and exclusion of taxa on any reef community type (as well 1170), thus impacting upon community structure and hence, function. In addition, scallop culture on the seabed is unlikely to occur on the majority of reef community types, but may occur on more mixed sediments. However, the maximum cover of aquaculture activities on each of the habitats is below 15% (Table 13) and the total cover of all aquaculture activities is 4.48% of reef habitat (1170) (Table 3).

Introduction of non-native species; As already outlined **o**yster culture may present a risk in terms of the introduction of non-native species as the Pacific oyster (*Crassostrea gigas*) itself is a non-native species. Recruitment of *C. gigas* has been documented in a number of Bays in Ireland and appears to have become naturalised (i.e. establishment of a breeding population) in two locations (Kochmann et al 2012; 2013) and may compete with the native species for space and food. In addition to having large number of oysters in culture, Kochmann et al (2013) identified short residence times and large intertidal areas as factors likely contributing to the successful recruitment of oysters in Irish bays. In addition, a recent study (Kochmann and Crowe, 2014) has identified heavy macroalgal cover as a potential factor governing successful recruitment, with higher cover resulting in lower recruitment. Oyster production in the Kenmare does not fulfil these criteria, as production is low (30 tonnes pa), the suitable habitat intertidally is low with high macroalgal cover and residence time is between 1.2-22.6 days. Therefore the risk of successful establishment of the pacific oyster in Kenmare River SAC is considered low.

In relation to the Manila clam (*Ruditapes philippinarum*), this species has been in culture in Ireland since 1984 and, to the best of our knowledge, no recruitment in the wild has been recorded. The operations are totally reliant on hatchery seed and are fully contained at all stages of the production cycle. The risk of naturalisation of this species is considered low, but should be kept under surveillance.

Table 8: Matrix showing, where possible, the characterising community types (or surrogates) sensitivity scores x pressure categories in Kenmare River SAC (ABPMer 2013a-h). Table 9 provides the code for the various categorisation of sensitivity and confidence

	Pressure Type																						
Community Type (EUNIS code)	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Extraction	Siltation (addition of fine sediments, pseudofaeces, fish food)	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments-sedimentation	Increased removal of primary production-phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
Zostera-dominated community (A5.533)	M-H (***)	M-VH (***)	M-VH (***)	M-VH (***)	VH (***)	VH (***)	M(*)	M (***)	M(*)	H (***)	NS (*)	H (***)	H (***)	NS (*)	H-VH (*)	H-VH (*)	H (**)	NS (*)	NS (*)	NEv	NEv	NS (***)	H-VH (**)
Maerl-dominated community (A5.51)	H (***)	H-VH (***)	H (***)	H-VH (***)	H-VH (***)	H-VH (***)	NS (*)	NS (*)	NS (*)	H(*)	NS (*)	H(*)	H (***)	NS (*)	H(**)	H(**)	H (***)	VH (***)	NS (*)	NE	NE	NE	VH (*)
Muddy fine sands dominated by polychaetes and *A. filiformis* community complex (Subtidal A5.33/A5.35)	NS (*)	L(*)	L(*)	L-M (*)	L(*)	L-M (*)	L-M (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L(*)	NS (*)	L(*)	L(*)	H (*)	NS (*)	NS (*)	NS (*)	NS (*)	L(*)	NS (*)
Fine to medium sand with crustaceans and polychaetes community complex (Intertidal and subtidal) (A5.23)	NS (*)	L(*)	L(*)	L-M (*)	L-M (*)	L-M (*)	L-M (*)	M(*)	L-M (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L-NS (***)	L-NS (***)	NS (***)	NS (*)	NS (*)	NS (*)	NS (*)	L(*)	NS (*)

	Pressure Type																						
Community Type (EUNIS code)	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Extraction	Siltation (addition of fine sediments, pseudofaeces, fish food)	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments-sedimentation	Increased removal of primary production-phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
Intertidal reef community complex (A3.21)**	NS (*)	NA	NA	NA	NS (*)	M-VH (*)	NA	NA	NS (*)	NS (*)	NS (*)	NS (*)	NE	NS (*)	NE	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Laminaria-dominated community complex (A3.21)**	NS (*)	NA	NA	NA	NS (*)	M-VH (*)	NA	NA	NS (*)	NS (*)	NS (*)	NS (*)	NE	NS (*)	NE	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Subtidal reef with echinoderms and faunal turf community complex (A4.1/4.2)	NS (*)	NA	NA	NA	NS (*)	M-VH (*)	NA	NA	NS (*)	NS (*)	NS (*)	NS (*)	NE	NS (*)	NE	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)

Note: *No sensitivity listed for this community type;No sensitivity listed for this community type (3.21) so using scores for A3.22.**

Table 9: Matrix showing the characterising species sensitivity scores x pressure categories for taxa in Kenmare River SAC (ABPMer 2013a-h). Table 9 provides the code for the various categorisation of sensitivity and confidence

	Pressure Type																						
Species	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Extraction	Siltation	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments- sedimentation	Increased removal of primary production- phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
Abra alba	L(*)	L (***)	L(*)	M (*)	NS (***)	M (*)	L(*)	NS (*)	NS (*)	L(*)	L(*)	NS (*)	NS (*)	NS (*)	L (***)	L-M (***)	L-M (*)	NS (*)	NS (*)	NS (***)	NEv	L (***)	NS (*)
Alcyonium digitatum	L-M (***)	NE	NE	NE	L(**)	M(*)	NA	NA	L(*)	NS (*)	NS (*)	NEv	NE	NS (*)	NE	M(*)	NEv	NS (*)	NS (*)	NEv	NEv	NS (*)	NS (*)
Angulus sp. (Moerella)	NS (*)	L(*)	L (***)	M(*)	NS (*)	H(*)	M-H (*)	NS (*)	L-M (*)	L(*)	NS (*)	NS (*)	Nev	L-NS (*)	NEv	NEv	M (*)	NS (*)	NS (*)	NS (*)	NEv	NEv	NS (*)
Bathyporeia spp.	NS (*)	L (***)	L (***)	L-M (*)	L (***)	L-M (*)	L-M (*)	L-M (*)	NS (*)	NS (*)	NS (*)	L-M (*)	L-M (*)	NS (*)	L-M (***)	L-M (***)	L-M (*)	NS (*)	NS (*)	NS (*)	NEv	NEv	NS (*)
Corynactis viridis	M-H (*)	NA	NA	NA	L(*)	H-VH (*)	NA	NA	M-H (*)	L(*)	NS (*)	NS (*)	NE	NS (*)	NE	NEv	NS (*)	NS (*)	NS (*)	NEv	NEv	NEv	NS (*)
Cliona celata	M (***)	NA	NA	NE	M (**)	L(*)	NA	NA	NEv	NS (***)	NS (*)	NS (***)	NE	NS (*)	NE	NEv	NS (*)	NS (*)	NS (*)	NEv	NEv	NEv	NS (*)
Caryophyllia smithi	H (**)	NA	NA	NE	H (***)	VH(*)	NA	NA	NS (*)	NS (*)	H(*)	NEv	NE	NS (*)	NE	NEv	NEv	NS (*)	NS (*)	NEv	NEv	NEv	MS (*)
Capitella spp.	L(*)	L (**)	L (**)	L(*)	L(*)	NS (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	L (***)	L (***)	NS (*)	NS (*)	NS (*)	NS (***)	L (***)	NS (***)	NS (*)
Corophium volutator	L (***)	L (***)	L (***)	L(*)	L (***)	L (***)	M(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	L (***)	L (***)	Nev	NS (*)	NS (*)	NA	NEv	L (***)	NS (*)
Cerastoderma edule	L(*)	L-M (*)	L-M (***)	L-H (*)	L (***)	L-M (*)	L-H (*)	NS (*)	L(*)	NS (*)	NS (*)	NS (*)	NS (**)	L-NS (*)	L-M (*)	L-M (*)	M (*)	M (*)	NS (*)	NS (*)	NEv	L-M (*)	NS (*)

	Pressure Type																						
Species	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Extraction	Siltation	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments-sedimentation	Increased removal of primary production-phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
Echinus esculentus	L-M (***)	NA	NA	NA	L (***)	H(*)	NA	NA	NS (*)	NS	NS (*)	NS	NE	NS (*)	NE	H(***)	NS (*)	L-M	NS	NEv	NEv	M-H	NS (*)
Euclymene oerstedii	NS (*)	NS (*)	M(*)	H(*)	NS (*)	H(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	M(*)	M(*)	NS (*)	NS (*)	NS (*)	NS (*)	NEv	NS (*)	NS (*)
Fabulina fabula	NS (*)	L-NS (*)	L-NS (*)	M(*)	NS (*)	M(*)	M-H(*)	L(*)	L(*)	NS (*)	NS (*)	L(*)	M-H (*)	L-NS (*)	NS-L (***)	L-NS (*)	M(*)	NS (*)	NS (*)	NS (*)	NEv	L-M (*)	NS (*)
Glycera sp.	NS (*)	L-M (***)	L-M (*)	M(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (**)	NS (***)	NS (*)	NS (***)	NS (***)	NS (*)	NS (*)	NS (*)	NA	NEv	NS (***)	NS (*)
Hydrobia ulvae	L-NS (*)	L (***)	L(*)	M (*)	NS (***)	L(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	L(*)	L(*)	L(*)	NS (*)	NS (*)	NEv	NEv	M (*)	NS (*)
Lanice conchilega	NS (*)	NS-L (***)	NS-L (***)	M-H (*)	NS (*)	M-H (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	M (*)	M (*)	M-H (*)	NS (*)	NS (*)	NS (*)	NEv	L (***)	NS (*)
Nephtys hombergii	NS (*)	L(*)	L(***)	L(*)	NS(**)	NS (*)	L(*)	NS (*)	NS(**)	NS (*)	NS (*)	NS (*)	NS(**)	NS (*)	NS (***)	NS (***)	NS (*)	M(*)	NS (*)	NS(**)	NEv	M (***)	NS (*)
Nephtys cirrosa	NS (*)	L (***)	L (***)	L(*)	NS (***)	NS (*)	L(*)	NS (*)	L(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	M (*)	M (*)	NS (*)	NS (*)	NEv	NEv	NS (*)
Nematoda	NS (***)	NS (***)	NS (***)	L(*)	NS (*)	NS (***)	NS (***)	NS (***)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	L (***)	L (***)	NS (***)	NS (*)	L(*)	NS (***)	NEv	L (***)	NS (*)
Protodorvillea kefersteini	NS (*)	NS (*)	NS (*)	L-M(*)	L(*)	L(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (*)	M(*)	NS (*)	NS (*)	NS (*)	NEv	NS (*)	NS (*)
Phaxas pellucidus	NS (*)	M(*)	M(*)	H(*)	NS (***)	M(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L(*)	L-NS	NEv	NEv	M(*)	NS (*)	NS (*)	NS (*)	NEv	NEv	NS (*)

Species	Pressure Type																						
	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Extraction	Siltation	Smothering (addition of materials biological or non-biological to the surface)	Changes to sediment composition- increased coarseness	Changes to sediment composition- increased fine sediment proportion	Changes to water flow	Increase in turbidity/suspended sediment	Decrease in turbidity/suspended sediment	Organic enrichment-water column	Organic enrichment of sediments- sedimentation	Increased removal of primary production- phytoplankton	Decrease in oxygen levels- sediment	Decrease in oxygen levels-water column	Introduction of non-native species	Removal of Target Species	Removal of Non-target species	Introduction of antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features
														(*)									
Pygospio elegans	L(*)	L (**)	M (***)	L-M (*)	L (***)	L-M (***)	L-M (*)	NS (**)	L-M (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	L (**)	L (**)	M (*)	NS (*)	NS (*)	NS (*)	NEv	NEv	NS (*)
Scoloplos armiger	NS (*)	L(*)	L-M (*)	H (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	M (***)	M (***)	M (*)	M (**)	NS (*)	NS (*)	NEv	NEv	NS (*)
Tubificoides spp.	NS (*)	NS (*)	L (**)	M (*)	NS (*)	L(*)	NS (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	NS (***)	NS (***)	NS (*)	NS (*)	NS (*)	NS (**)	NEv	NEv	NS (**)
Notomastus sp	NS (*)	L (***)	L (***)	L-M (*)	L(**)	L(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (**)	NS (*)	L(*)	L(*)	M(*)	NS (*)	NS (*)	NS (*)	NEv	NS (***)	NS (*)
Melinna palmata	NS (***)	NS (***)	NS (***)	M(*)	L (***)	M(*)	NS (*)	NS (*)	NS (*)	L(*)	NS (***)	NS (***)	NS (***)	NS (*)	NS (***)	NS (***)	L(*)	NS (*)	NS (*)	NS (***)	NEv	M (***)	NS (*)
Mysella bidentata	NS (*)	NS (*)	L-M (*)	M(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (**)	NS (**)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L-M (*)	NS (*)	NEv	NA	NS (*)
Prionospio spp.	NS (*)	NS (***)	NS (*)	L(*)	L (***)	L(*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	NS (***)	NS (***)	L(*)	NS (*)	NS (*)	NS (***)	NEv	NS (***)	NS (*)
Scalibregma inflatum	NS (*)	L(*)	M(*)	M(*)	NS (***)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	NS (***)	NS (***)	NA	NS (*)	NS (*)	NS (*)	NS (*)	NEv	NS (*)
Spiophanes bombyx	L(*)	L (***)	L(***)	L(*)	NS (*)	L(*)	L(*)	L(*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)	L (***)	L (***)	L(*)	NS (*)	NS (*)	NS (*)	NEv	L (***)	NS (*)
Thyasira flexuosa	L(*)	L (***)	L(*)	M-H (*)	NS (*)	M-H (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	M (***)	M (***)	M (*)	NS (*)	NS (*)	NS (***)	NEv	NS (***)	NS (*)

Table 10: Codes of sensitivity and confidence applying to species and pressure interactions presented in Tables 8 and 9.

Species x Pressure Interaction Codes for Tables 8 and 9	
NA	Not Assessed
Nev	No Evidence
NE	Not Exposed
NS	Not Sensitive
L	Low
M	Medium
H	High
VH	Very High
*****	Low confidence
******	Medium confidence
*******	High Confidence

Conclusion 1: It is concluded that, with three exceptions, the aquaculture activities individually and in-combination do not pose a risk of significant disturbance to the conservation features for habitats (and community types) in Kenmare River based primarily upon the spatial overlap and sensitivity analysis (Tables 11 and 12). The exceptions are the activity (**scallop culture**) occurring over **Maerl dominated community, *Pachycerianthus multiplicatus* community complex** and ***Zostera* dominated community**. In spite of the relatively benign nature of the culture proposed (placement of scallop seed on seafloor) it is still considered potentially disturbing to these extremely sensitive community types types, primarily by virtue of the dredging activity associated with the culture practice and the uncertain nature of the placement of large quantities of scallop seed upon seagrass beds and subsequent scuba diving activities. The location of an intertidal oyster cultivation operation (T06/500A) over a *Zostera* bed is considered disturbing.

Table 11: Interactions between the relevant aquaculture activities and the habitat feature Large shallow inlets and bays (1160) constituent communities with a broad conclusion on the nature of the interactions.

			1160 – Large shallow inlets and bays				
Culture Type	**Location**	**Method**	***Zostera*-dominated community**	***Maerl*-dominated community**	***P. multiplicatus* community**	**Muddy fine sands dominated by polychaetes and *Amphiura filiformis* community**	**Fine to medium sand with crustaceans and polychaetes community complex**
Mussel (*Mytilus edulis)* on ropes	Subtidal	Intensive	**N/A**	**N/A**	**N/A**	**Disturbing: Yes** **Justification:** The high density of stock will impact on seafloor due to organic enrichment (faeces and pseudofaeces) and stock drop off. However the species have high recoverability and are tolerant. This activity overlaps 0.31% of this community type.	**Disturbing: Yes** **Justification:** The high density of stock will impact on seafloor due to organic enrichment (faeces and pseudofaeces) and stock drop off. However the species have high recoverability and are tolerant. This activity overlaps 2.76% of this community type
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	Intensive	**Disturbing: Yes** **Justification:** Given the highly sensitive nature of this community type any activity is likely to have some impact either by shading by trestles on grass or compaction by transport routes to/through the trestles and increased organic enrichment. This activity overlaps 18.05% of this community type	**N/A**	**N/A**	**Disturbing: No** **Justification:** Published literature (Forde et al., 2015) suggests that activities occurring at trestle culture sites are not disturbing. The stock is confined in bags, is sourced from hatcheries and is diploid/triploid.	**Disturbing: No** **Justification:** Published literature (Forde et al., 2015) suggests that activities occurring at trestle culture sites are not disturbing. The stock is confined in bags, is sourced from hatcheries and is diploid/triploid.
Scallops (*Pecten maximus*) on seabed	Subtidal	Extensive	**Disturbing: Yes** **Justification:** Given the highly sensitive nature of this community type any activity is likely to have some impact either by increasing species (albeit native) biomass/density and the disturbance risks associated with harvest activities (dredging). This activity overlaps 2.52% of this community type.	**Disturbing: Yes** **Justification:** Given the highly sensitive nature of the community type in question any activity is likely to have some impact either by increasing species (albeit native) biomass/density and the disturbance risks associated with harvest activities (dredging). This activity overlaps 27.89% of this community type..	**Disturbing: Yes** **Justification:** Given the highly sensitive nature of the community type in question any activity is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 100% of this community type.	**Disturbing: No** **Justification:** The activities associated with this culture type is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 0.92% of this community type.	**Disturbing: No** **Justification:** The activities associated with this culture type is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 1.01% of this community type.
Salmon (*Salmo salar)* in net pens	Subtidal	Intensive	**N/A**	**N/A**	**N/A**	**Disturbing: Yes** **Justification:** The community and species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.08% of this community type	**Disturbing: Yes** **Justification:** The community and species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.31% of this community type
Cumulative Impact Aquaculture			**Disturbing: Yes** **Justification:** This community type is not tolerant of any overlap of any activity. The cumulative pressure of likely impacting activities on this community type is 20.55%**.**	**Disturbing: Yes** **Justification:** This community type is not tolerant of any overlap of any activity. The cumulative pressure of likely impacting activities on this community type is significant at 27.89%**.**	**Disturbing: Yes** **Justification:** The cumulative pressure of likely impacting activities on this community type is significant at 100%**.**	**Disturbing: No** **Justification:** The cumulative pressure of likely impacting activities is 0.39% on this community type. (<15% threshold).	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 3.07% on this community type. (<15% threshold).

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Table 12 cont'd**: Interactions between the relevant aquaculture activities and the habitat feature Large shallow inlets and bays (1160) constituent communities with a broad conclusion on the nature of the interactions.**

			1160 – Large shallow inlets and bays			
Culture Type	**Location**	**Method**	**Coarse sediment dominated by polychaetes community complex**	**Intertidal reef community complex**	***Laminaria*-dominated community complex**	**Subtidal reef with echinoderms and faunal turf community complex**
Mussel (*Mytilus edulis)* on ropes	Subtidal	Intensive	**Disturbing: Yes** **Justification:** The high density of stock will impact on seafloor due to organic enrichment (faeces and pseudofaeces) and stock drop off. This activity overlaps 3.31% of this community type	**Disturbing: Yes** **Justification:** The community type is sensitive to shaing, stock drop off, smothering and siltation (faeces and pseudofaeces). This activity overlaps 5.05E-03% of this community type	**Disturbing: Yes** **Justification**: The community type is sensitive to shaing, stock drop off, smothering and siltation (faeces and pseudofaeces). This activity overlaps 1.35% of this community type.	**Disturbing: Yes** **Justification:** The community type is sensitive to shaing, stock drop off, smothering and siltation (faeces and pseudofaeces). This activity overlaps 2.01% of this community type
Oysters (*Crassostrea gigas*) in bags & trestles	Intertidal	Intensive	**N/A**	**Disturbing: Yes** **Justification:** The community type is sensitive to shading, smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.22% this community type.	**Disturbing: Yes** **Justification:** The community type is sensitive to shading, smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.48% this community type.	**Disturbing: Yes** **Justification:** The community type is sensitive to shading, smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.03% this community type.
Scallops (*Pecten maximus*) on seabed	Subtidal	Extensive	**Disturbing: Yes** **Justification:** The activities associated with this culture type is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 0.47% of this community type.	**Disturbing: Yes** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge. However, the activities associated with this culture type are likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 0.15% of this community type.	**Disturbing: Yes** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge. However, the activities associated with this culture type is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 5.97% of this community type.	**Disturbing: Yes** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge. However, the activities associated with this culture type is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 0.19% of this community type.
Salmon (*Salmo salar)* in net pens	Subtidal	Intensive	**Disturbing: Yes** **Justification:** The community type and species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.56% of this community type.	**N/A**	**Disturbing: Yes** **Justification:** The community type is considered tolerant to pressures from activity. The species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.30% of this community type.	**Disturbing: Yes** **Justification:** The community type is considered tolerant to pressures from activity. The species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.35% of this community type.
Cumulative Impact Aquaculture			**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 4.34% on this community type. (<15% threshold).	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 0.37% on this community type. (<15% threshold).	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 8.60% on this community type. (<15% threshold).	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 2.58% on this community type. (<15% threshold).

Table 13: Interactions between the relevant aquaculture activities and the community type feature Reefs (1170) constituent communities with a broad conclusion on the nature of the interactions.

			1170 – Reef		
Culture Type	**Location**	**Method**	**Intertidal reef community complex**	***Laminaria*-dominated community complex**	**Subtidal reef with echinoderms and faunal turf community complex**
Mussel (*Mytilus edulis*) on ropes	*Subtidal*	*Intensive*	-	**Disturbing: Yes** **Justification**: The community type is sensitive to shading, stock drop off, smothering and siltation (faeces and pseudofaeces). This activity overlaps 1.99% of this community type.	**Disturbing: Yes** **Justification:** The community type is sensitive to shaing, stock drop off, smothering and siltation (faeces and pseudofaeces). This activity overlaps 2.1% of this community type
Oysters (*Crassostrea gigas*) in bags & trestles	*Intertidal*	*Intensive*	**Disturbing: Yes** **Justification:** The community type is sensitive to shading, smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.55% this community type.	**Disturbing: Yes** **Justification:** The community type is sensitive to shading, smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.53% this community type.	**Disturbing: Yes** **Justification:** The community type is sensitive to shading, smothering and siltation (faeces and pseudofaeces). This activity overlaps 0.03% this community type.
Scallops (*Pecten maximus*) on seabed	*Subtidal*	*Extensive*	**Disturbing: Yes** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge. However, the activities associated with this culture type are likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 0.11% of this community type.	**Disturbing: Yes** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge. However, the activities associated with this culture type is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 5.46% of this community type.	**Disturbing: Yes** **Justification:** It is unlikely that the culture operation will occur over this community type given the difficulty likely to be encountered operating a dredge. However, the activities associated with this culture type is likely to have some impact mainly due to disturbance risks associated with harvest activities (dredging). This activity overlaps 0.19% of this community type.
Salmon (*Salmo salar*) in net pens	*Subtidal*	*Intensive*	-	**Disturbing: Yes** **Justification:** The community type is considered tolerant to pressures from activity. The species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.28% of this community type.	**Disturbing: Yes** **Justification:** The community type is considered tolerant to pressures from activity. The species would be sensitive to the activity by virtue of persistent organic enrichment on the seafloor. This activity overlaps 0.35% of this community type.
Cumulative Impact Aquaculture			**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 0.66% on this community type. (<15% Threshold)	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 8.26% on this community type. (<15% Threshold)	**Disturbing: No** **Justification:** the cumulative pressure of likely impacting activities is 2.67% on this community type. (<15% Threshold)

8.4 Assessment of the effects of shellfish production on the Conservation Objectives for Harbour Seal in Kenmare River SAC.

Kenmare River SAC is designated for the Harbour Seal (*Phoca vitulina*). The distribution of the harbour seal and site use within the Kenmare River SAC are provided in Figure 3. The conservation objectives for this species are listed in Table 1 and can be found in detail in NPWS (2013a; 2013b). Recent harbour seal surveys (NPWS 2010, 2011, 2012) show the Kenmare River has maintained its importance on a regional and national scale in terms of Harbour Seal numbers, as indicated in earlier surveys (Cronin *et al*., 2004; Heardman *et al.,* 2006). While the conservation status of the species is therefore considered favourable at the site, the interactions between harbour seals and the features and aquaculture activities carried out in the SAC must be ascertained.

The interactions between aquaculture operations and aquatic mammal species are a function of:

1. The location and type of structures used in the culture operations - is there a risk of entanglement or physical harm to the animals from the structures or is access to locations restricted?

2. The schedule of operations on the site – is the frequency such that they can cause disturbance to the animals?

The proposed activities must be considered in light of the following attributes and measures for the Harbour Seal:

- Access to suitable habitat – number of artificial barriers
- Disturbance – frequency and level of impact
- Harbour Seal Sites:
    - Breeding sites
    - Moulting sites
    - Resting sites

Restriction to suitable habitats and levels of disturbance are important pressures that must be considered to ensure the maintenance of favourable conservation status of the harbour seal and implies that the seals must be able to move freely within the site and to access locations considered important to the maintenance of a healthy population. They are categorised according to various life history stages (important to the maintenance of the population) during the year. Specifically they are breeding, moulting and resting sites (Figure 3). It is important that the access to these sites is not restricted and that disturbance, when at these sites, is kept to a minimum. The structures used in culture of oysters (bags on trestles) may form a physical barrier to seals when both submerged and exposed on the shoreline such that the access to haul-out locations might be blocked. Activities at sites and during movement to and from culture sites may also result a disturbance events such that the seals may note an activity (head turn), move towards the water or actually flush into the water. While such disturbance events might have been documented, the impact of these disturbances at the population level has not been studied more broadly (National Research Council, 2009).

Intertidal oyster culture using bags and trestles has been conducted within the Kenmare River since the early 1990's. The current level of production, which remains quite small (<30 tonnes) is represented as licenced activities in Figure 4. It is considered that, given the favourable conservation status of Harbour Seals within the SAC represented by stable numbers since 2009 (NPWS 2012) that the current production levels (and activities associated with them) are conducive with favourable conservation status. However, some shellfish culture activities do physically overlap with designated seal sites identified in the SAC. In Coongar Harbour an oyster farm (licensed) and an application site for mussel culture is in very close proximity to a seal moulting site and in Ardgroom Harbour a mussel farm (licensed) overlaps a seal site (breeding). In Coonger Harbour, the seal site in question has multiple recordings of seals and therefore, would be considered an important location (Oliver O'Cadhla, NPWS - personal communication). The aquaculture site in question, has structures confined to the northern portion of the site and cannot expand beyond immediate areas based upon the topography of the site. This ensures that the activity will not occur in close proximity to the seal haul-out location. An expansion of intertidal aquaculture activity to areas in the immediate vicinity of the haul out locations would likely increase the risk of disturbance of the seals during the moulting period. The mussel application appears to be an expansion of existing operations it is therefore, likely the seals will be habituated or tolerant of disturbance from this activity.

In Ardgroom Harbour a single sighting was recorded at a mussel culture site during 2000 and 2001 (Lyons, 2003) – it is assumed, given the lack of natural structures at the site in question, that seal was hauled out on mussel rafts. The site in question has been licenced (and active) since 1992.

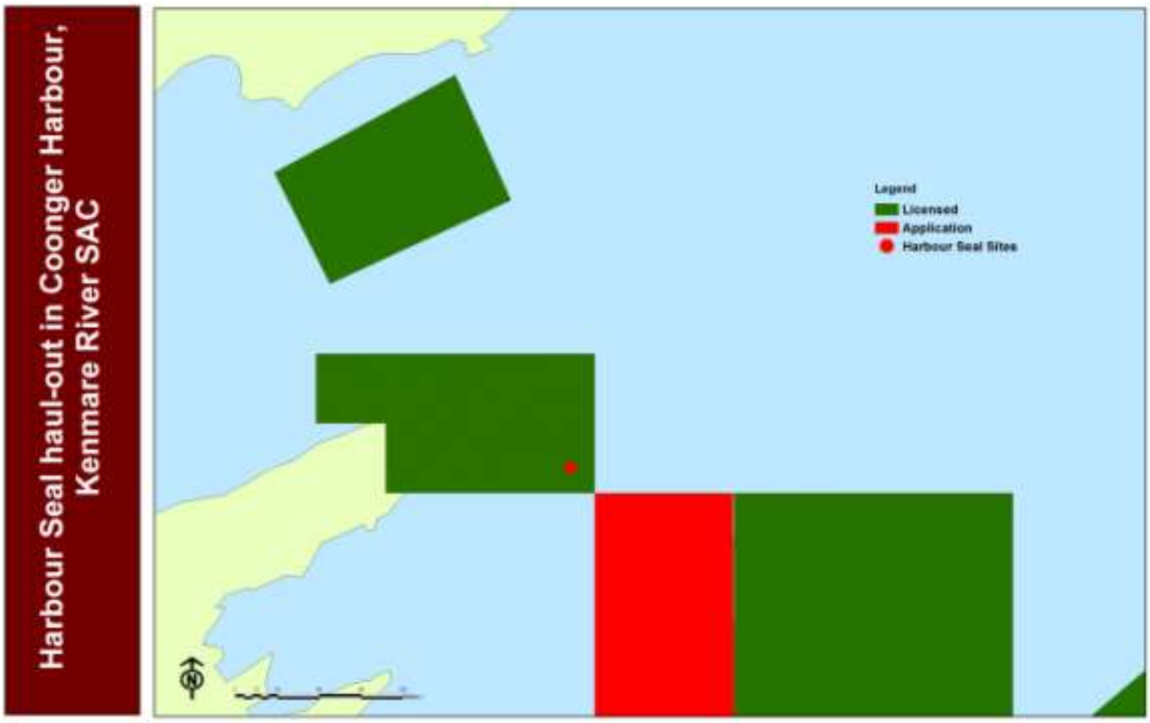
It should be noted that a finfish culture site within Killmakilloge Harbour is in close proximity to designated seal sites (breeding, moulting and haul out). As indicated previously, seal interactions with marine finfish cages have been identified (Aquaculture Stewardship Council, 2012). The risk to seals (as predators) result from their interaction with netting where if incorrectly configured (loose) the risk of drowning due to being entangled is increased. While a risk of entanglement in netting may present, it is not considered likely given that slack netting also presents a risk to culture organism in that it reduces the containment area. In terms of mitigation and in order to minimise risk to seals, the operators should employ a range of management actions including stock management (density control, regular removal of mortalities from cages), use of seal blinds and appropriate net tensioning. These practices are all considered suitable methods to minimise negative interactions between seals and finfish culture (Aquaculture Stewardship Council 2012). The use of Acoustic Deterrent Devices (ADDs) is not considered practical. Lethal actions to remove seals are only allowed under licence, the criteria which are determined by NPWS (Section 42 of the Wildlife Act, 1976 (as amended)).

Notwithstanding this, it would appear that the current level of activity at the sensitive times of the year (breeding and moulting, i.e. May to September) is sufficient to maintain stable seal counts at the site.

Conclusion 1: With one exception, the current levels of licenced shellfish and finfish culture and proposed applications are considered non-disturbing to harbour seal conservation features.

One exceptions to this conclusion is outlined above in Coonger Harbour (refer Figure 8). It is recommended that the boundaries for this intertidal oyster culture site be redrawn to exclude the area overlapping the seal haul-out locations which will mitigate further any disturbance risk to seals.

Figure 12: Aquaculture activity (oyster farm) overlapping Harbour Seal moulting site in Coongar Harbour.



Conclusion 2: Under the conditions described above, finfish culture is not considered disturbing to the Harbour Seal.

8.5 Assessment of the effects of aquaculture production on the Conservation Objectives for Otter and migrating Salmon in Kenmare River SAC.

<u>Otter</u>

As the aquaculture production activities within the SAC spatially overlap with otter (*Lutra lutra*) territory, these activities may have negative effects on the abundance and distribution of populations of the species.

The Kenmare River SAC is designated for the otter (*Lutra lutra*); the conservation objectives for such are listed in Table 1. The risk of negative interactions between aquaculture operations and aquatic mammal species is a function of:

1. The location and type of structures used in the culture operations- is there a risk of entanglement or physical harm to the animals from the structures?

2. The schedule of operations on the site – is the frequency such that they can cause disturbance to the animals?

Shellfish Culture: Shellfish culture operations are likely to be carried out in daylight hours. The interaction with the otter is likely to be minimal given that otter foraging is primarily crepuscular. It is unlikely that these culture types pose a risk to otter populations in the Kenmare River. Impacts can be discounted on the basis of the points below:

The proposed activities 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 aquaculture and fisheries activities.
- Shellfish production activities are unlikely to pose any risk to otter populations through entrapment or direct physical injury.
- The structures and activities associated this form of oyster culture structures are raised from the seabed (0.5m -1m) and are oriented in rows, thus allowing free movement through and within the site.
- Disturbance associated with vessel and foot traffic could potentially affect the distribution of otters at the site. However, the level of disturbance is likely to be very low given the likely encounter rates will be low dictated primarily by tidal state and in daylight hours.

Conclusion 3: The current levels of licenced shellfish culture and applications are considered non-disturbing to otter conservation features.

Finfish Culture: The structures (nets) involved in finfish culture may pose an entanglement hazard to otters. However if site conditions as outlined in the seal section above (Section 8.4) are maintained this risk will be greatly mitigated.

Conclusion 4: The current levels of licenced finfish culture and applications are considered non-disturbing to otter conservation features.

Salmon (*Salmo salar*)

The Blackwater River runs into the north shore of Kenmare River SAC and is designated as an SAC for salmon (Blackwater River (Kerry) SAC).

Significant declines in sea survival and reduced returns to the coast and rivers of Atlantic salmon in recent decades have been recorded in Ireland (Salmon Management Task Force Report (Anon., 1996); O'Maoileidigh *et al*., 2004; Jackson *et al*., 2011). The reasons for the reduced sea survival remain unclear and speculation has covered such issues as global warming effects (Friedland *et al*., 2000; Friedland *et al*., 2005), changes in locations or availability of prey species, loss of post-smolts as by-catch in pelagic fisheries, increased fishing pressure, riverine habitat changes and sea lice infestation (Finstad et al., 2007; SSCWSS 2013). However, despite many years of study, processes contributing to the high mortality of juvenile Atlantic salmon between ocean entry and the first winter at sea remain poorly understood (Jones, 2009).

The results of a long term study carried out in the Burrishoole system in Co. Mayo (Jackson *et al*., 2011) show a strong and significant trend in increasing marine mortality of Atlantic salmon originating from the Burrishoole system. They would also point to infestation of outwardly migrating salmon smolts with the salmon louse (*L. salmonis*) as being a minor and irregular component of marine mortality in the stocks studied and not being implicated in the observed decline in overall survival rate. The results of this study have been corroborated by studies carried out by the Marine Institute as part of a detailed investigation into the potential impacts of sea lice on a number of other river systems, including the Newport River (Jackson *et al*., 2013a).

The Irish State has developed a comprehensive control and management strategy for sea lice infestations on farmed salmonids. This systems is underpinned by research dating back to the early 1990s and was the basis for the introduction of the original lice monitoring programme (Jackson and Minchen, 1993). Subsequent research (Jackson *et al.,* 2000; Jackson *et al.,* 2002) informed the development of a set of management protocols published by the Department of Marine in 2000 (Anon., 2000). The full implementation of these protocols resulted in improved sea lice control on farmed salmon (O'Donohoe *et al*., 2013). There has been a policy of utilising research to ensure that the most up to date and effective treatment and management regimes are in place to control sea lice on Irish farms and this has included research into techniques to assess the most effective treatment regimes (Sevatdal *et al*., 2005) and the sources of sea lice infestation in the marine environment (Jackson *et al.*, 1997; Copley *et al*., 2005; Copley *et al.,* 2007).

The monitoring and control system in place is comprehensive, transparent and independent. The Irish management and control system is widely regarded as best international practice because it has low treatment trigger levels, is based on independent inspection regimes, has a robust follow-up on problem areas and Ireland is the only country in the world to publish the results of the independent state run inspection programme in full each year (O'Donohoe *et al.,* 2013). Following the introduction of the "S*trategy for improved pest control on Irish salmon farms*" in 2008 by the Department of Agriculture Fisheries and Food there were significant improvements in sea lice management in Ireland (Jackson, 2011).

The control strategy is aimed at implementing a more strategic approach to lice control at a bay level and targeting efforts on the spring period where there is a potential for impacts on wild smolts embarking on their outward migration. The effectiveness of the system is witnessed by trends in sea lice infestation on farmed fish in the peak period for wild salmon smolt migration having shown a strong downward trend since the introduction of the new management strategy (Jackson *et al.,* 2013). As indicated previously, in relation to **disease interactions**, any risks of disease transfer between cultured finfish and wild fish are mitigated by the management systems currently in place. In summary, Council Directive 2006/88/EC on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals form the legislative basis that governs the monitoring and management of disease outbreaks in mariculture operations in Ireland. For diseases not listed in this Directive, a Code of Practice and Fish Health Handbook has been developed jointly by the State and industry with the primary objectives of disease prevention and control.

Active veterinary surveillance and intervention has assisted in reducing the prevalence and spread of many pathogens. In addition, the principles outlined in the Fish Health Handbook mentioned above such as improved biosecurity practices on farms, fallowing sites to break transmission cycles, veterinary inspection of fish prior to transfer, single year class stocking, coordinating treatments and harvesting within embayments etc have mitigated the transmission of pathogenic organisms.

Notwithstanding the issues highlighted above, it is concluded that aquaculture production in the Kenmare River SAC does 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)**

8.6 Assessment of the effects of shellfish production on the Conservation Objectives for Maerl in the Kenmare River SAC.

Maerl dominated community occurs in certain areas (Ardgroom and Killmakilloge Harbours) which are outside of the Qualifying Interests for which the Kenmare River SAC was designated but are still within the SAC boundary. Maerl, the characterising species of this community, is listed as an Annex V species and as it is within the SAC boundary it must be afforded protection.

Aquaculture activity (suspended mussel culture) within Ardgroom harbour spatially overlaps (1.84%) with the Maerl dominated community and may have negative effects on the distribution and quality of this community type (Figure 13). The potential effects of this aquaculture type which are listed in Table 5, include current alteration, increased deposition and shading. Table 8 lists the sensitivities of community types to various pressure types according to ABPMer (2013b). According to ABPMer (2013b) Maerl habitats are restricted to shallow coastal waters by requirements for light penetration hence this species has a high sensitivity to increased turbidity, is sensitive to decrease in water flow speed and organic enrichment of sediments. Based on the findings of the later report the proposed activity (suspended mussel culture) will therefore have an adverse effect on the species for the following reasons:

Maerl is very highly sensitive to the following which may result as a consequence of suspended culture operations:

- Shading (due to structures at the surface and/or in water column)
- Siltation (addition of fine sediments, pseudofaeces).
- Smothering (addition of materials biological or non-biological to the surface).
- Change in water flow due to permanent/semi-permanent structures placed in the water column).
- Change in turbidity/suspended sediment/Increased suspended sediment turbidity.

Conclusion 5: Suspended mussel culture in Ardgroom Harbour is potentially disturbing to Maerl dominated community.

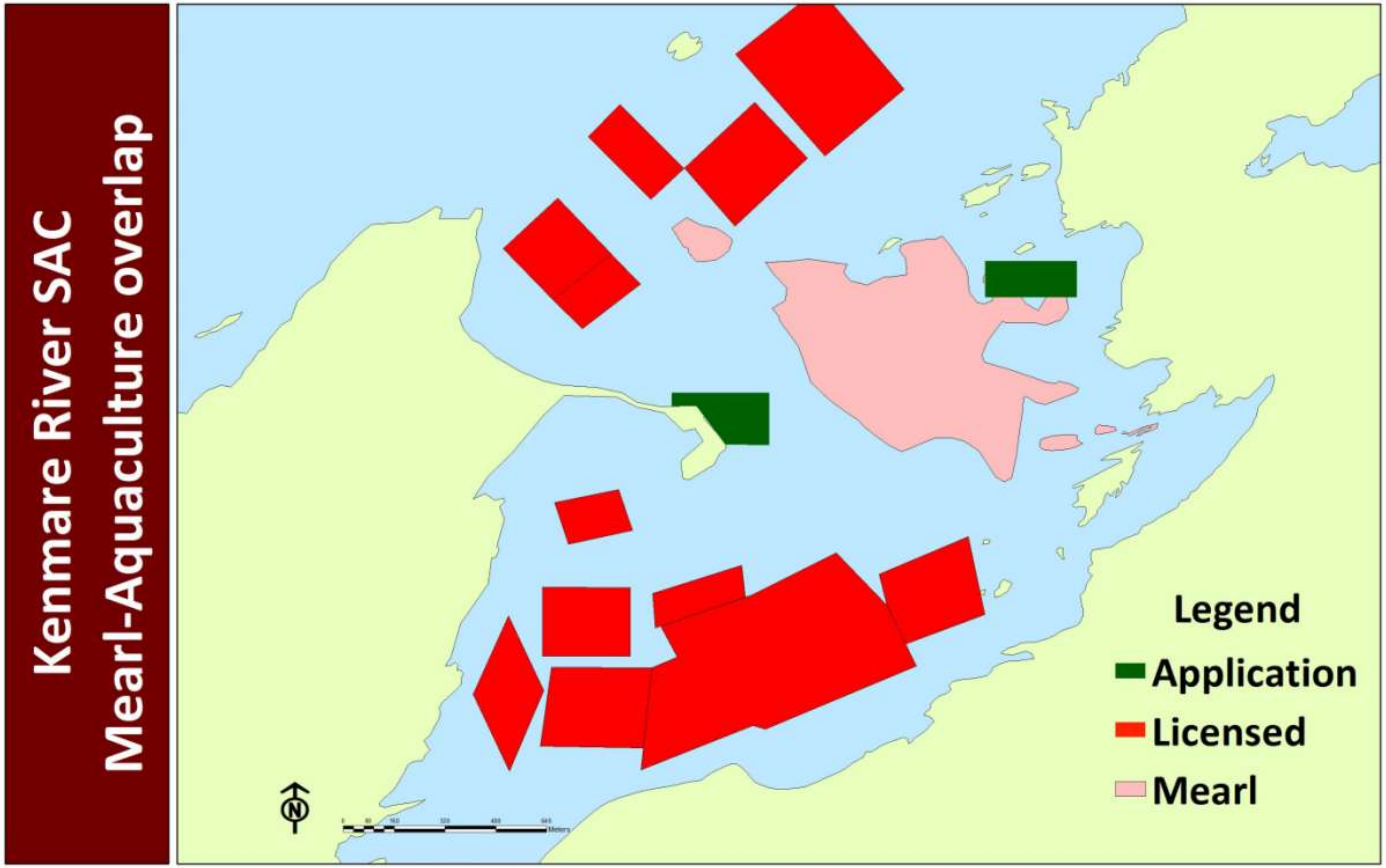


Figure 13. Aquaculture activities overlapping Mearl habitat in Kenmare River SAC.

9. Assessment of Fisheries Activities

9.1. Fisheries:

The risk assessment framework for fisheries follows, where feasible, EC guidance (2012) and includes elements of risk assessment from Fletcher (2002, 2005). The qualitative and semi-quantitative framework is described in Marine Institute (2013) and criteria for risk categorization is shown in Tables 14 and 15 below.

The framework uses categorical conditional probability matrices of likelihood and consequence to assess the risk of an activity to a conservation feature. Categorical likelihood and consequence scores for each such 'incident' (fishery-designated feature interactions) are provided by expert judgment and a base literature resource which has been pre-compiled for each habitat type defined in the COs.

Separate conditional probability matrices for habitats and designated species are used to assess risk. In the case of habitats the consequence criteria largely follow the definitions and methodologies used for AA of projects and plans. In the case of species the consequence categories relate to the degree to which populations and their supporting habitats may be negatively affected by the given activity.

9.1.2. Sensitivity of characterizing species and marine communities to physical disturbance by fishing gears

- The approach and rationale to assessment of the sensitivity of species and habitats to fishing activities and the information used in this assessment is similar to that outlined for aquaculture
- NPWS (2012b) provide lists of species characteristic of the habitats that are defined in the Conservation Objectives. The sensitivity of these species to various types of pressures varies and the species list varies across habitats.
- Pressures due to fishing are mainly physical in nature i.e. the physical contact between the fishing gear and the habitat and fauna in the habitat causes an effect.
- Physical abrasive/disturbing pressures due to fishing activity of each metier maybe classified broadly as causing disturbance at the seabed surface and/or at the sub-surface.
- Fishing pressures on a given habitat is related to vulnerability (spatial overlap or exposure of the habitat to the gear), to gear configuration and action, frequency of fishing and the intensity of the activity. In the case of mobile gears intensity of activity is less relevant than frequency as the first pass of the gear across a given habitat is expected to have the dominant effect (Hiddink *et al.*. 2007).
- Sensitivity of a species or habitat to a given pressure is the product of the resilience of the species to the particular pressure and the recovery capacity (rate at which the species can recover if it has been affected by the pressure) of the species. Morphology, life history and biological traits are important determinants of sensitivity of species to pressures from fishing and aquaculture.

- The separate components of sensitivity (resilience, recoverability) are relevant in relation to the persistence of the pressure
    - For persistent pressures, i.e. fishing activities that occur frequently and throughout the year, recovery capacity may be of little relevance except for species/habitats that may have extremely rapid (days/weeks) recovery capacity or whose populations can reproduce and recruit in balance with population reduction caused by fishing. In all but these cases, and if resilience is moderate or low, then the species may be negatively affected and will exist in a modified state. Such interactions between fisheries and species/habitats represent persistent disturbance. They become significantly disturbing if more than 15% of the community is thus exposed (NPWS 2012b).
    - In the case of episodic pressures i.e. fishing activities that are seasonal or discrete in time both the resilience and recovery components of sensitivity are relevant. If resilience is low but recovery is high, relative to the frequency of application of the pressure, than the species/community will be in favourable conservation status for a given proportion of time
- The sensitivities of some species, which are characteristic (as listed in the COs) of benthic communities, to physical pressures similar to that caused by fishing gears, are described above.
- In cases where the sensitivity of a characterising species (NPWS 2011b) has not been reported this risk assessment adopts the following guidelines
    - Resilience of certain taxonomic groups such as emergent sessile epifauna to physical pressures due to all fishing gears is expected to be generally low or moderate because of their form and structure (Roberts *et al.* 2010).
    - Resilience of benthic infauna (eg bivalves, polychaetes) to surface pressures, caused by pot fisheries for instance, is expected to be generally high as such fisheries do not cause sub-surface disturbance
    - Resilience of benthic infauna to sub-surface pressures, caused by toothed dredges and to a lesser extent bottom otter trawls using doors, may be high in the case of species with smaller body sizes but lower in large bodied species which have fragile shells or structures. Body size (Bergman and van Santbrink 2000) and fragility are regarded as indicative of resilience to physical abrasion caused by fishing gears
    - Recovery of species depends on biological traits (Tillin *et al.* 2006) such as reproductive capacity, recruitment rates and generation times. Species with high reproductive capacity, short generation times, high mobility or dispersal capacity may maintain their populations even when faced with persistent pressures but such environments may become dominated by these (r-selected) species. Slow recovery is correlated with slow growth rates, low fecundity, low and/or irregular recruitment, limited dispersal capacity and long generation times

Table 14. Risk categorization for fisheries and designated habitat interactions (see: Marine Institute 2013). Colours indicate risk category. Disturbance is defined as that which leads to a change in characterising species. Such disturbance may be temporary or persistent depending on the frequency of impact and the sensitivity of the receiving environment. Colours indicate the probable need for mitigation of effects from green (no mitigation needed), to yellow (mitigation unlikely to be needed but review on a case by case basis), orange (mitigation probably needed) and red (mitigation required)

Habitats			**Consequence criteria**					
			Activity is not present or has no contact with habitat	Activity occurs and is in contact with habitat	Up to 15% overlap of fishery and habitat seasonally.	Over 15% overlap of fishery and habitat seasonally.	Over 15% of habitat disturbed persistently leading to cumulative impacts	Impact is effectively permanent due to severe habitat alteration.
			No change due to fishing activity can occur	Individual effects on characterising species but this is undetectable relative to background natural variability	Seasonal change in characterising species and community structure and function	Seasonal change in characterising species and structure and function	Persistent change in characterising species, structure and function	Biodiversity reduction associated with impact on key structural species
						Frequency of disturbance < recovery time. Non-cumulative	Frequency of disturbance> recovery time. Cumulative	No recovery or effectively no recovery
Likelihood	**%**	Level	**0**	**1**	**2**	**3**	**4**	**5**
Highly likely	>95	**5**	0	5	10	15	20	25
Probable	50-95	**4**	0	4	8	12	16	20
Possible	20-50	**3**	0	3	6	9	12	15
Unlikely	1-20	**2**	0	2	4	6	8	10
Remote	1	**1**	0	1	2	3	4	5

Table 15. Risk categorization for fisheries and designated species interactions (Marine Institute 2013)

Species			**Consequence criteria**					
			Activity is not present and individuals or population cannot be affected	Activity present. Individuals in the population affected but effect not detectable against background natural variability	Direct or indirect mortality or sub-lethal effects caused to individuals by the activity but population remains self-sustaining	In site population depleted by the activity but regularly sub-vented by immigration. No significant pressure on the population from activities outside the site	Population depleted by the activity both in the site and outside of the site. No immigration or reduced immigration	Population depleted and supporting habitat significantly depleted and unable to continue to support the population
Likelihood	**%**	Level	**0**	**1**	**2**	**3**	**4**	**5**
Highly likely	>95	**5**	**0**	**5**	**10**	**15**	**20**	**25**
Probable	50-95	**4**	**0**	**4**	**8**	**12**	**16**	**20**
Possible	20-50	**3**	**0**	**3**	**6**	**9**	**12**	**15**
Unlikely	1-20	**2**	**0**	**2**	**4**	**6**	**8**	**10**
Remote	1	**1**	**0**	**1**	**2**	**3**	**4**	**5**

9.1.3. Spatial overlap of fisheries and qualifying interests

Percentage spatial overlap of fisheries on marine community types within each Qualifying Interest is shown below in Table 16. The footprint of each fishery is the area of the polygon within which the fishery takes place and is an exaggeration of the actual area over which gear is deployed, especially in the case of static gears (Traps, Gill nets, Tangle nets, Trammel Nets). In some cases (Hooks and Lines) there is overlap with the marine community type but no pressure or footprint as the gear is not in contact with the seabed.

Table 16. Spatial overlap of fisheries and marine community types in Kenmare River SAC. There are no fisheries on intertidal mobile sands or on shingle communities. Spatial overlap of demersal and pelagic trawls, as shown by Vessel Monitoring System data, is not quantified and is presented as absent or present. Overlap of multiple fisheries occur on community types making the calculation of cumulative spatial overlap impractical.

QI/SCI	Marine Community Type	Fishing current	Trap - lobster	Trap - crab	Trap - shrimp	Trap - Nephrops	Dredge - scallop	Gill net	Tangle net crayfish	Trammel netting bait	Otter trawl - demersal	Mid-water trawl	Hooks and Lines	Hand gathering winkles
Large shallow inlets and bays [1160]	Intertidal mobile sand community complex	Yes	0	0	0	0	0	0	0	0	0	0	0	0
Large shallow inlets and bays [1160]	Zostera dominated community	Yes	0	0	50	0	0	0	0	0	0	0	0	
Large shallow inlets and bays [1160]	Co-occurrence Zostera and maerl community complex	Yes	100	100	100	0	0	0		100	0	0	0	
Large shallow inlets and bays [1160]	Maërl-dominated community	Yes	95	95	98	0	0	0	0	95	0	0	0	
Large shallow inlets and bays [1160]	Pachycerianthus multiplicatus community	Yes	0	0	100	0	0	0	0	0	0	0	0	
Large shallow inlets and bays [1160]	Muddy fine sands dominated by polychaetes and Amphiura filiformis community complex	Yes	20	20	17	1	1	1	14	20	1	1	33	
Large shallow inlets and bays [1160]	Fine to medium sand with crustaceans and polychaetes community complex	Yes	55	55	28	2	9	1	0	55	1	1	0	
Large shallow inlets and bays [1160]	Coarse sediment dominated by polychaetes community complex	Yes	36	36	7	0	6	1	18	36	1	1	2	
Large shallow inlets and bays [1160]	Shingle	Yes	0	0	0	0	0	0	0	0	0	0	0	0
Large shallow inlets and bays [1160]	Intertidal reef community complex	Yes	0	0	0	0	0	0	0	0	0	0	0	1
Large shallow inlets and bays [1160]	Laminaria-dominated community	Yes	34	34	30	1	0	1	3	34	1	1	0	
Large shallow inlets and bays [1160]	Subtidal reef with echinoderms and faunal turf community complex	Yes	30	30	11	0	6	1	12	30	1	1	1	
Reefs [1170]	Intertidal reef community complex	Yes	0	0	0	0	0	0	0	0	0	0	0	1
Reefs [1170]	Laminaria-dominated community	Yes	38	38	35	1	0	1	2	38	1	1	0	

Reefs [1170]	Subtidal reef with echinoderms and faunal turf community complex	Yes	37	37	12	0	0	1	12	37	1	1	1	

9.1.3. Risk assessment of the impact of fishing gears on marine benthic communities

- The list of fishing activities (métiers) operating in Kenmare Bay is described above
- The sensitivity of marine communities, which are the subject of the COs to physical disturbance that may be caused by fishing gears is in Table 8.
- The risk assessment framework outlined in Table 14 and Table 15 for habitats and species respectively provides a rationale for assessing and scoring risk posed by fishing activities to the conservation objectives. More detailed explanation is provided in Marine Institute (2013).
- One of the risk assessment criteria for habitats is the % overlap of the activity and each habitat. The overlap of fisheries and marine community types within those habitats is in presented in Table 16.
- Risk scores for effects of individual fisheries on marine community types and species are in Table 17.

9.2 Fisheries Risk profile

9.2.1. Marine Community types

9.2.1.1. Trap fisheries for lobster, crab, shrimp and *Nephrops*

- Trap fisheries may pose a risk to sensitive habitats such as Zostera and Maerl due to abrasion and disturbance caused by pots, ropes and anchors. The effect will depend on the intensity and frequency of the activity and the gear configuration in terms of pot spacing, number of anchors used, type of rope etc. Trap fisheries for *Nephrops* will not occur on this ground. Shrimp fisheries may occur on the *Pachycerianthus* community and there is a low risk of impact to this species.
- Trap fisheries may pose some risk to kelp reef communities and to sub-tidal faunal turf reefs depending on the intensity of the potting activity. This risk is likely to be low however against background variability in these communities.
- Pot fisheries pose no risk to sedimentary habitats

9.2.1.1. Dredge fisheries for scallop

- Dredge fisheries for scallop occurs on sub-tidal reef community and may have an impact on this community. There is some uncertainty as to the location of this fishery and its relation to aquaculture applications for bottom culture of scallop
- Dredging for surf clams may occur in sedimentary habitats in Kenmare River (spatial analysis not shown). They are not currently fished, no surveys of their distribution have been undertaken and the site is not a classified production area for this species. The risk posed to sedimentary habitats from a surf clam fishery is low.

9.2.1.2. Set net fisheries

- Gill net, tangle nets and trammel nets are used to capture mixed fish, crayfish and bait respectively
- The extent of trammel netting is unknown and here it is assumed to have the same footprint of the lobster fishery as trammel nets are used primarily to catch bait species for lobster pots. If they are used the associated anchors and footropes may impact Zostera and Maerl beds and may have lesser impacts on kelp reefs which are less sensitive to disturbance than Zoster or Maerl.
- Tangle nets and gill nets are likely to be used in deeper waters away from kelp reefs or Zostera and Maerl beds.

9.2.1.3. Bottom trawl fisheries

- Bottom trawling in Kenmare Bay occurs mainly in the outer part of the site in the muddy fine sand community complex. Fishing in the eastern part of the site by vessels >15m is close to zero. It also occurs on medium fine sand. Annual VMS effort for vessels >15m, between 2006-2012 in the site was approximately 350 hrs. The distribution of VMS points indicates that over 15% of the muddy fine sand community is fished. Fishing occurs in all months of the year
- Muddy fine sand communities, particularly suspension feeders and crustaceans, are sensitive to fishing pressure from trawls but this depends on intensity of the fishing pressure. The community is not sensitive to low levels of trawling (a single pass for instance). Recovery time is prolonged compared to coarser substrates due to the fact that such habitats are mediated by a combination of biological, chemical and physical processes compared to coarse substrates which are dominated by physical processes (ABPMer 2013. Muddy sands. Appendix F,). Recovery times from impacts may take years.
- The intensity of trawling by vessels over 15m in length in outer Kenmare River could be classed as medium (using scales provided by the Beaumaris approach to sensitivity assessment, ABPMer 2012. Muddy sands. Appendix F, p. 71) and some of the habitat probably experiences more than a single pass of the gear per annum. Activity by vessels under 15m is unquantified. The community therefore may be impacted. Impact would increase if fishing effort escalated.
- In Kenmare the anthozoan *Virgularia mirabilis* occurs in the muddy fine sand community but is unlikely to be affected by trawling as it occurs in the inner Bay.

9.2.1.3. Mid-water trawl fisheries and hook and line fisheries

- These fisheries are not expected to impact marine habitats in Kenmare Bay

9.2.1.3. Hand gathering of periwinkles

- Hand gathering of periwinkles occurs on intertidal reef communities. There is a low risk of impact in such communities due to trampling pressure. However, although the intensity of the activity is unknown it is unlikely to be such that significant effects would occur.

Table 17. Risk assessment for fisheries-marine community type interactions in Kenmare River SAC.

QI/SCI	Marine Community Type	Trap - lobster	Trap - crab	Trap - shrimp	Trap - Nephrops	Dredge - scallop	Gill net	Tangle net crayfish	Trammel netting bait	Otter trawl - demersal	Mid-water trawl	Hand gathering winkles	Hooks and Lines
Large shallow inlets and bays [1160]	Co-occurrence Zostera and maerl community complex	16	16	16					16				
Large shallow inlets and bays [1160]	Zostera dominated community			12									
Large shallow inlets and bays [1160]	Maërl-dominated community	16	16	16					16				
Large shallow inlets and bays [1160]	Pachycerianthus multiplicatus community			9									
Large shallow inlets and bays [1160]	Muddy fine sands dominated by polychaetes and Amphiura filiformis community complex	4	4	4	4		4	4	4	12	4		2
Large shallow inlets and bays [1160]	Fine to medium sand with crustaceans and polychaetes community complex	4	4	4	4		4		4	12	4		
Large shallow inlets and bays [1160]	Coarse sediment dominated by polychaetes community complex	4	4	4			4	4	4	12	4		2
Large shallow inlets and bays [1160]	Intertidal reef community complex											6	
Large shallow inlets and bays [1160]	Laminaria-dominated community	9	9	9	9		4	4	9	4	4		
Large shallow inlets and bays [1160]	Subtidal reef with echinoderms and faunal turf community complex	9	9	9		8	4	4	9	4	4		2
Reefs [1170]	Laminaria-dominated community	9	9	9	9		4	4	9	4	4		
Reefs [1170]	Subtidal reef with echinoderms and faunal turf community complex	9	9	9			4	4	9	4	4		2
Large shallow inlets and bays [1160]	Intertidal reef community complex											6	

9.2.2. Species

9.2.2.1. Harbour Seal

- Harbour seals haul out in sheltered waters, typically on sandbanks and in estuaries, but also in rocky areas and may swim upstream into freshwater. They undertake smaller scale foraging movements (30km from the haul out site) and migrations than grey seal. Pups remain in their natal area after weaning (Wilson *et al*. 2003, Cronin *et al*. 2008). Space use maps for Harbour seals tagged in Kenmare River shows very limited movement outside of Kenmare River SAC (Figure 14).

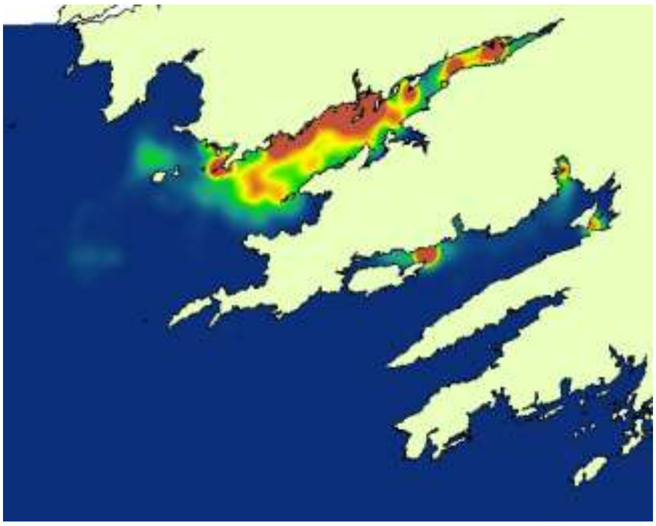


Figure 14. Space use maps for tagged Harbour seals in Kenmare river (source: Cronin *et al*. 2008)

- Number of Harbour seals in Kenmare River declined slightly from 413 to 390 between Census counts in 2003 and 2011
- Tangle nets are used at the mouth of Kenmare River within the foraging range of seals at the site.
- Gill net use is reported by vessels over 15m in Kenmare River within the foraging range of seals from Kenmare River
- Pelagic trawling for sprat (with herring by-catch) occurs in Kenmare River and east to the upper reaches of the Bay.
- Demersal trawling occurs in outer Kenmare River but within the Kenmare River SAC.
- Potting for shrimp occurs in inner Kenmare river while lobster and crab potting, with the possible use of trammel nets for bait, occurs along the south and north shores of the outer Bay.
- By-catch risk is highest for gill net fishing and pelagic fishing in inner Kenmare River. There may be a by-catch in trammel nets. The pelagic fishery for sprat and pot fisheries may cause disturbance at haul out locations which are mainly in the inner Bay on north and south shores.

Cumulative risk posed by fisheries may result in sub-lethal and lethal effects on individual seals but the risk to the population may be relatively low. However, total annual by-catch of Harbour Seal in Kenmare River is unknown.

- Risk of by catch, prey depletion and disturbance does not exceed a value of 6 and is considered to be low.

9.2.2.1. Otter

- Otter (*Lutra lutra*) is listed in Annex II of the Habitats Directive. Otter is common throughout freshwater systems in Ireland and also occurs in coastal marine habitats.
- There is a low risk of capture of otters in lobster pots and trammel nets set in shallow water (<5m). Such mortality has been documented elsewhere.
- Because of the intensity of pot fishing, unknown levels of associated use of trammel nets and documented accounts of mortality of otter in parlour creels in particular there is some likelihood of capture of individual otters. As creels and trammels are unlikely to be deployed within the preferred dive range of otters in the Irish lobster fishery the likelihood of capture is thought to be unlikely

10. In-combination effects of aquaculture, fisheries and other activities

Given the uncertainty in relation to scallop fishing the assessment of in-combination effects of this activity and scallop culture (which is in-effect a type of fishery activity) are difficult to estimate. It is likely that the 'wild' fishery activities will not occur in the aquaculture plots if they are actively maintained. Conservative estimates of percentage overlap of wild-fishery activities on Marine Community Types are provided in Table 16. Notwithstanding the difficulty estimating the extent of fishery activities, the likely in-combination of potentially disturbing fishery (Table 16) and aquaculture activities on Marine Community types (Tables 12, 13) do not exceed the 15% threshold identified in guidance documents (NPWS 2013b).

Those fishery activities that overlap with sensitive community types or represent a risk identified in Table 17 should be subject to mitigation measures the extent of which are beyond the scope of this report. Other fishery activities have little or no overlap with aquaculture activities and are subject to separate management actions.

Other activities leading to potential impacts on conservation features relate to harvest of seaweed on intertidal reef communities. There is little known concerning the level of harvest from these intertidal reef communities. The impact is likely two-fold, direct impact upon the reefs by removal of a constituent species and impact upon intertidal sediments as a consequence of travel across the shore to the harvest sites. The likely overlap between these activities and intertidal shellfish culture is considered small as the (reef) habitat is not considered suitable for shellfish culture and low levels of this culture method overlaps this habitat. Seaweed harvesting requires a foreshore licence administered by the Department of Environment, Community and Local Government. The level of transport across the intertidal area is unknown, but it is presumed that the routes are well defined.

Seal watching cruises are conducted in Kenmare. The extent of these activities are confined to the inner portions of Kenmare River SAC and do not overlap with the aquaculture operations. It is assumed that these activities are subject to a separate AA process?

There are a number of activities which are terrestrial in origin that might result in impacts on the conservation features of the Kenmare River SAC. Primary among these are point source discharges from municipal and industrial units (Shellfish Pollution Reduction Programme, DECLG). There are five urban waste water treatment plants in the general vicinity of the SAC. These are found in Ardgroom, Kenmare, Sneem, Kilgarvan, Eyeries. The pressure derived from these facilities is a discharge that may impact upon levels of dissolved nutrients, suspended solids and some elemental components e.g. aluminium in the case of water treatment facilities. It should be noted that the pressures resulting from fisheries and aquaculture activities are primarily morphological in nature. It was, therefore, concluded that given the pressure resulting from say, a point discharge location (e.g. urban waste-water treatment plant or combined sewer overflow) would likely impact on physico-chemical parameters in the water column, any in-combination effects with aquaculture or fisheries activities are considered to be minimal or negligible.

No other activities resulting in morphological and/or disturbance pressures were identified or could be quantified.

11. SAC Aquaculture Appropriate Assessment Concluding Statement and Recommendations

In the Kenmare River SAC there are a range of aquaculture activities currently being carried out or proposed. Based upon this and the information provided in the aquaculture profiling (Section 5), the likely interaction between this aquaculture and conservation features (habitats and species) of the site were considered.

An initial screening exercise resulted in a number of habitat features and species being excluded from further consideration by virtue of the fact that no spatial overlap of the culture activities was expected to occur. The habitats and species excluded from further consideration were1014 Marsh Snail *Vertigo angustior*, 1220 Perennial vegetation of stony banks, 1230 Vegetated sea cliffs of the Atlantic and Baltic coasts, 1330 Atlantic salt meadows (Glauco-Puccinellietalia maritimae), 1410 Mediterranean salt meadows (*Juncetalia maritimi*), 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes"), 2130 Fixed coastal dunes with herbaceous vegetation (grey dunes), 4030 European dry heaths and 6130 Calaminarian grasslands of the *Violetalia calaminariae* and Submerged or partially submerged sea caves (8330).

9.1 Habitats

A full assessment was carried out on the likely interactions between aquaculture operations (as proposed) and the Annex 1 habitats 1160 (Large Shallow Inlets and Bay), and 1170 (Reefs). The likely effects of the aquaculture activities (Species, structures) were considered in light of the sensitivity of the constituent community types and species of the Annex 1 habitats.

Conclusion and Recommendation - Aquaculture Activities: Of the 11 community types listed under the remaining habitat features (1160 and 1170) two (Intertidal mobile sand community complex and Shingle) were also excluded from further analysis as they had no overlap with aquaculture activities.

Based upon the scale of spatial overlap and the relatively high tolerance levels of the habitats and species therein, the general conclusions relating to the interaction between current and proposed aquaculture activities with habitats is that consideration can be given to licencing (existing and applications) in the Annex 1 habitats – 1160 (Large Shallow Inlets and Bays and 1170 (Reefs) with the exception of activities overlapping the following community types:

1. **Zostera-dominated community**- This habitat is not tolerant of any overlap of any activity. The cumulative pressure of likely impacting activities on this habitat is 20.55%**.**
2. **Maerl-dominated community -** This habitat is not tolerant of any overlap of any activity. The cumulative pressure of likely impacting activities on this habitat is significant at 27.89%**.**
3. ***Pachycerianthus multiplicatus* community -** The cumulative pressure of likely impacting activities on this habitat is significant at 100%**.**

It is important to note that licenced areas impacted by aquaculture that might be redrawn to exclude any overlap with sensitive habitats should include a sufficient buffer zone to allow for mapping resolution and/or visual enforcement of exclusion. Furthermore, there is still the risk that wild fishery interests might still dredge for scallop in these areas; therefore, it is recommended that some understanding should be arrived at between aquaculture management and fishery management interests in relation to these areas.

Also, it might be worth discussing whether the scallop culture activities as described (i.e., with harvest by dredging) can be considered an ‘aquaculture’ activity as distinct from a wild fishery, given that seeding is questionable and that ‘culture’ areas are very large.

Finally, the likely interaction between the proposed aquaculture activities and the Annex V species Maerl was assessed in areas where the maerl habitat did not fall under the Qualifying Interests but was still within the SAC boundary. It is **also concluded** that the aquaculture activity (suspended mussel culture) in Ardgroom Harbour is disturbing to this community type.

9.2 Species

The likely interactions between the proposed aquaculture activities and the Annex II Species Harbour Seal (*Phoca vitulina*) and Otter (*Lutra lutra*) were also assessed. The objectives for these species in the SAC focus upon maintaining the good conservation status of the population and consider certain uses of intertidal habitats as important indicators of status. The aspect of the culture activities that could potentially disturb the Harbour seal status relates to movement of people and vehicles within the sites as well as accessing the sites over intertidal areas and via water.

Conclusion and Recommendation: It is acknowledged in this assessment that the favourable conservation status of the Harbour seal (*Phoca vitulina*) has been achieved given current levels of aquaculture production within the SAC. On this basis, the current levels of licenced aquaculture (existing and renewals) are considered non-disturbing to harbour seal conservation features. However, there is one exception:

- Aquaculture activity (oyster farm) overlaps a Harbour Seal moulting site in Coongar Harbour and is recommended that the site boundaries be redrawn to exclude the overlap of harbour seal haul-out site.

In relation to new applications, given the lack of spatial overlap or the fact that applications which are adjacent to haul-out sites represent expansion of existing activities (and tolerance or acclimatisation has occurred) it is considered that the aquaculture activities proposed (applications) do not pose a threat to the harbour seal in the Kenmare River SAC.

The current levels of licenced aquaculture operations and applications are considered non-disturbing to Otter (*Lutra lutra)* conservation features.

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Tools for Assessment and Planning of Aquaculture Sustainability

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Improved modelling approaches for shellfish production in coastal, intertidal and offshore environments

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SUMMARY

This report presents an overview of improved modelling approaches developed for shellfish culture within intertidal, coastal and offshore environments. In many European countries, a lack of suitable sites for shellfish production is one of the constraints preventing expansion of the sector. Furthermore, even if an area is available, there are biological and physical requirements that must be met to support culture. Shellfish producers, and the regulators that oversee planning and licensing, require information to support the decision making process, to ensure shellfish are grown in the most suitable locations and production does not adversely affect other activities or ecosystem beyond acceptable limits.

Three modelling approaches are evaluated here using a series of case studies. The first couples Earth observation (EO) data to assess site suitability and production potential and potential trade-offs between intertidal and offshore sites (Section 2). The second couples a biogeochemical-hydrodynamic model to a shellfish aquaculture model to assess carrying capacity, production potential and environmental impact of a large-scale commercial farm in an offshore environment (Section 3). The third approach is a flushing study which considers the suitability of a coastal bay for additional shellfish production (Section 4).

The main recommendation from the work is the need to use models that consider spatial and temporal scales rather than discrete points. Choice of model will depend on the purpose and information required. Some of the more computationally intensive approaches may only be necessary for large-scale farms or farms where there could potentially be an unacceptable impact to the wider ecosystem or marine protected areas.

The advantage of modelling different production scenarios and alternative sites is also highlighted. Modelling multiple scenarios can help producers identify the most suitable location and also evaluate the trade-offs between different sites and what this means for production and impacts. Each approach demonstrates an improved method that can support decision makers and increase transparency in the decision making process by providing the information necessary to make an informed and more objective decision.

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1. Introduction

Shellfish aquaculture in Europe is dominated by the production of mussels and oysters in coastal and intertidal environments. The main cultured species are the Blue mussel (*Mytilus edulis*), Mediterranean mussel (*Mytilus galloprovincialis*) and Pacific oyster (*Crassostrea gigas*). In 2016, over 36000 tonnes of mussels were produced and over 83000 tonnes of oysters were produced, most of which was Pacific oyster (FAO, 2018). The major mussel producing countries are Spain (60% of total production), France (16%), Greece (6%), Germany (6%), Ireland (4%) and UK (4%). France dominates oyster production, producing 77% of Pacific oysters in 2016, followed by Ireland (9%) and Italy (4%).

The availability of suitable locations for culture is a key constraint to further expansion of shellfish aquaculture in Europe. To support future development, producers and licensing authorities must identify locations that could be used. Models can be used to help stakeholders determine the suitability of a site for shellfish farming, assess carrying capacity and determine production potential. They are particularly useful in the decision-making process, where they can be used to help producers consider the feasibility of an operation and regulators can use model outputs to help decide whether a licence should be granted. A range of individual based models and/or population scale models have been developed over recent years to assess growth and production performance of mussels and oysters (Pouvreau et al., 2006; Ferreira et al, 2007; Barillé et al., 2011; Filgueira et al., 2011; Hawkins et al., 2013ab). On their own, these models are useful for assessing growth and production potential, but for planning, the spatial and temporal variation of environmental conditions must also be considered within the area to make sure aquaculture is located in the most appropriate locations and production is optimised within carrying capacity limits.

Three modelling approaches were evaluated using three case studies (Table 1.1.). Most shellfish production in Europe occurs in coastal and intertidal areas, however due to competition over space and resources, there is growing interest in moving further offshore. The first modelling approach evaluated here, demonstrates the use of Earth observation (EO) data coupled to a shellfish growth model to assess site suitability and production potential for intertidal and offshore locations on the West coast of France. This allows stakeholders to assess the trade-offs between intertidal and offshore areas and can be used to optimise production in the most suitable locations. The second approach also considers offshore culture, but this is at a recently established large-scale mussel farm in the English Channel. In this approach, a biogeochemical-hydrodynamic model was coupled to a shellfish aquaculture model to assess carrying capacity, production potential and environmental impact. The third approach focuses on a coastal bay in Ireland and uses a circulation model coupled with a particle tracking model to evaluate tidal flushing and water renewal rates and considers the use of hydrodynamic-biogeochemical models coupled to growth models to estimate carrying capacity.

Table 1.1: Summary of the modelling approaches developed or adapted in TAPAS for shellfish production

	France	**UK**	**Ireland**
System	Offshore cages and longlines	Offshore longlines	Longlines
Species	Oysters (*C.gigas*)	Mussel (*M. edulis)*	Mussel (*M. edulis*)
Modelling approach	EO data coupled to shellfish growth model	Biogeochemical-hydrodynamic model coupled to aquaculture model	Hydrodynamic model coupled to growth model

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2. Intertidal and offshore culture of oysters in Bourgneuf Bay, France (University of Nantes)

2.1. Background

Bourgneuf Bay on the French Atlantic coast, just south of the Loire estuary (Fig. 2.3), has a long history of bivalve aquaculture (notably of Pacific oyster, *Crassostrea gigas*, and blue mussel, *Mytilus edulis*). It is a macrotidal bay with a maximum tidal amplitude of 6 m; 100 km^2 of the total bay area (340 km^2) is intertidal. The bay supports important economic activity for *ca.* 300 companies, mostly small family-owned and -operated enterprises. The bay is ranked fifth in France, with an oyster production of *ca.* 5300 metric tons. As in many coastal bays of the French Atlantic coast, oyster culture covers much of the intertidal zone. Recently, farmers in the area have expressed interest in assessing the potential of moving oyster culture to new sites offshore to add to the existing area available to farm. Preliminary experiments have provided some empirical evidence of the suitability of the offshore environment for shellfish culture (Mille et al. 2008; Glize & Meneur, 2018). There is therefore a need to consider the implications that moving further offshore would have for growth and production.

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As for the intertidal zone, conditions in the offshore environment are highly variable over space and time, which would be expected to result in spatially variable growth and productivity; some areas within the offshore environment of the bay are expected to better foster growth than others, and should therefore be targeted for future farm leasing. Likewise, shellfish aquaculture concerns several discrete stages (spat production, growing out, and fattening or finishing), and some may be better suited to the offshore or to the intertidal environment, and *vice versa*. Aquaculture in the offshore and in the intertidal zones are expected to be complementary in this way, and the strategy to be taken needs to be considered to optimize moving parts of production offshore.

Different scenarios have been explored based on feedback from oyster producers from Bourgneuf Bay, as well as from the representative of oyster producers in Marennes-Oléron Bay, the most important site for Pacific oyster production in France (44000 tons in 2016). As suggested by the producers, we paid a particular attention to the pre-growing phase (first year) of the three-year growing cycle. We propose metrics to assess the growth performance of the most common spat sizes grown by producers. The final year of the growing phase has also been considered, particularly the time to reach the marketable size and various market calibres of interest. Simulations of off-shore growth also assessed weight able to be achieved for the main markets (Christmas, the peak sales period, as well as a secondary summer market). Finally, the possibility to use offshore facilities for a short period of time in fall for finishing/fattening of oysters of a certain marketable size was evaluated, considering the gain in soft tissue to obtain fleshy oysters that corresponds to a higher Quality Index (*Fines* or *Spéciales*) that can be sold at a higher price.

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The modelling approach evaluated here demonstrates the use of Earth Observation (EO) data to drive a shellfish growth model in order to assess and compare site suitability and production potential for offshore locations for a variety of growth scenarios.

2.2. Description of the modelling approach

A generic (i.e., non-species specific), mechanistic approach to modelling organismal growth as a function of their environmental conditions, Dynamic Energy Budget (DEB) theory was applied here to the Pacific oyster, *Crassostrea gigas*. The DEB model used in the present study to simulate oyster growth was derived from the standard model described by Kooijman (2010), first applied to *C. gigas* by Pouvreau et al. (2006). Except for the ingestion half-saturation coefficients, X_k and X_{ky}, all parameter values were based on the work of Bernard et al. (2011), which refined the processes of energy allocation to gametogenesis and resorption, and of Thomas et al. (2016), which introduced total suspended matter (TSM) as an additional forcing variable in order to take into account the influence of high TSM concentration on the ingestion function. The latter is necessary given the high turbidity of the study site and its influence on oyster growth (Gernez et al., 2017). X_k and X_{ky} were calibrated and validated as part of the current work for Bourgneuf Bay using in situ oyster growth data previously collected from both intertidal and offshore environments by a regional oyster-growing collective (Mixed Syndicate for the Development of Aquaculture and Fishing in Pays de la Loire (SMIDAP)). The overall scheme (Figure 2.1), equations, and parameters of the Pacific oyster DEB model are described in detail in Thomas et al. (2016), and calibration and validation of the ingestion coefficients of the current work are presented in Figure 2.2.

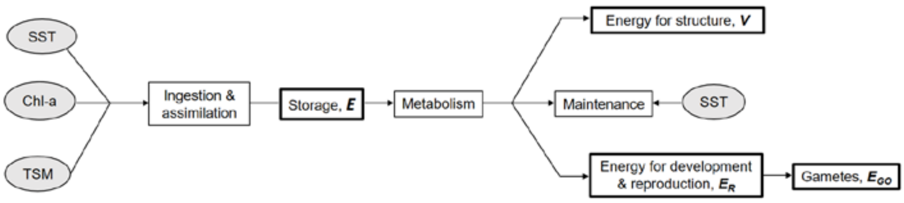

Figure 2.1. Dynamic Energy Budget schema; adapted from Thomas et al. (2016).

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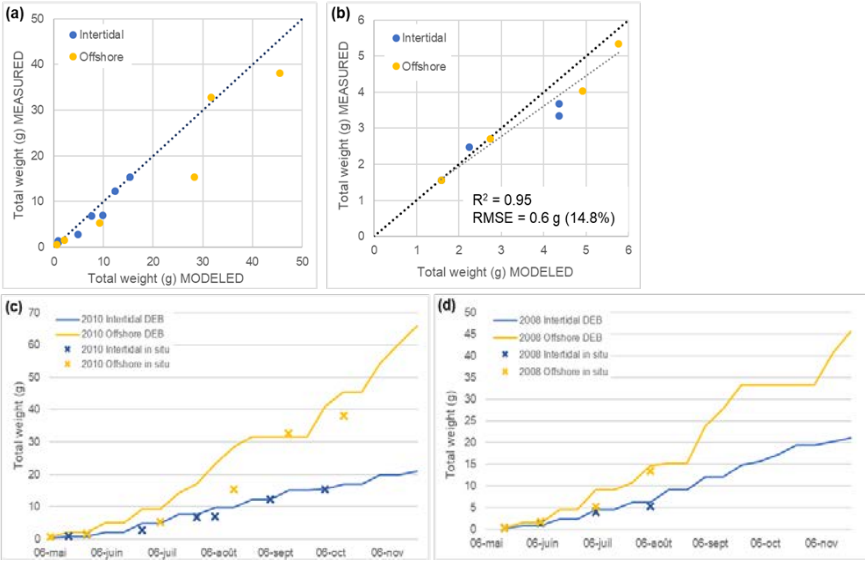

Figure 2.2. Dynamic Energy Budget ingestion coefficients (a, c) calibrated (X_k = 0.5; X_{ky} = 22.5) using 2010 *in situ* measurements, and (b, d) validated using 2008 *in situ* measurements from both the intertidal zone (blue) and offshore (yellow).

The three marine environmental parameters used to drive the DEB model, sea surface temperature (SST), total suspended matter (TSM) concentration, and chlorophyll-a (Chl-a) concentration as a proxy for food availability (mostly phytoplankton), were obtained via EO. SST data were obtained from the Advanced Very High Resolution Radiometer (AVHRR) operated by the US National Oceanic and Atmospheric Administration (NOAA), through application of the NOAA operational split-window algorithm. TSM and Chl-a concentrations were obtained from the European Space Agency's Medium Resolution Imaging Spectrometer (MERIS) in full spatial resolution (300 m), with existing algorithms to obtain TSM (Binding et al. (2010)) and Chl-a (OC4; NASA (2010)) concentrations locally-tuned for Bourgneuf Bay specifically (i.e., calibrated and validated using separate matchups between in situ and satellite datasets for the bay; Figure 2.3). All SST, TSM, and Chl-a products were processed at and provided by Plymouth Marine Laboratory, aggregated to ten-day averages from 2003-2011 to create the regular time series data needed to run the model, given irregular overpass frequency (2-3 days) and gaps due to cloudiness of the original data.

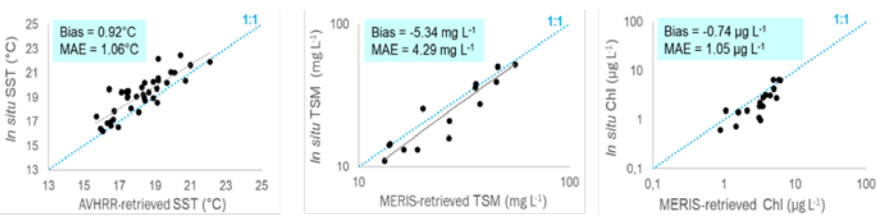

Figure 2.3. Validation of locally-tuned (a) SST, (b) TSM, and (c) Chl-a algorithms for retrieval and mapping of values from satellite imagery.

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Three growth scenarios were assessed: pre-growing, final year of growing, and fattening/finishing (Table 2.1), following the feedback from oyster producers. Accordingly, DEB simulations were run from March 1 to December 6 for each of the nine full years for which all forcing data were available (from 2003 and 2011), for spat with an initial length of 1.5 cm, total weight of 0.4 g (T6-T8 according to the measurement used by French hatcheries, https://www.francenaissain.com/), and dry flesh mass of 0.05 g, and for 18-months oysters with an initial length of 6.5 cm, total weight of 20 g (T30, oyster at the end of the pre-growing phase), and dry flesh mass of 0.3 g. The final shell length from each year was used to allometrically calculate and map the mean total weight using a regionally calibrated relationship (TW = L3 * 0.076; g). A finishing/fattening phase was also run, using a Calibre 3 (65g) adult as input, from September 28 through December 6 and considering the Quality Index, the percentage of drained flesh weight to the total weight of the oyster; a measure of fullness.

Table 2.1. General overview of simulated growth scenarios

Scenario	Growing period	Initial size	Total weight (g)
Pre-growing	Mar. 1 – Dec. 6	Spat (T6-T8)	0.4
Final year of growing	Mar. 1 – Dec. 6	18-months oyster (end of the pre-growing phase; T30)	20
Fattening/finishing	Sep. 28 – Dec. 6	Adult (Caliber 3)	65

2.3. Model output

The model output comprises oyster growth (shell length, transformed allometrically to total weight as described above, and dry flesh mass) maps at the same timestep as the input data (i.e., every ten days). Spawning events are also modelled, and their timing can be output in map format. Given the underlying interest of our case study, to optimize aquaculture site selection in the offshore environment, total weight over time was considered to be the most relevant base parameter, as this influences market demand and price.

Growth of total weight over time was then further transformed into several industry-meaningful growth performance indicators, using key market timings and market weight thresholds identified through consultation of producers and professionals from Bourgneuf and the neighbouring Marennes-Oléron Bay. These include those examples mapped for offshore in Bourgneuf Bay and existing farms in the intertidal zone in Figure 2.4: (a) days until the smallest spat size reach target sale size (T25; approximately 18g); (b) days until minimum adult market size (30g) is reached; (c) weight (g) obtained by adults for the (main) December market; and (d) Quality Index (drained flesh weight/total weight (%)) obtained by adults for the (main) December market. Indicators are relevant to the production of various life stages (spat production, growing adults, and fattening/finishing), and can easily be adapted to other user-defined criteria (e.g., the timing the weight of a certain calibre of oyster is achieved; growth for secondary summer market or another target date), by altering threshold values or dates. A complete list of the indicators selected for further work in Bourgneuf Bay is provided in Table 2.2.

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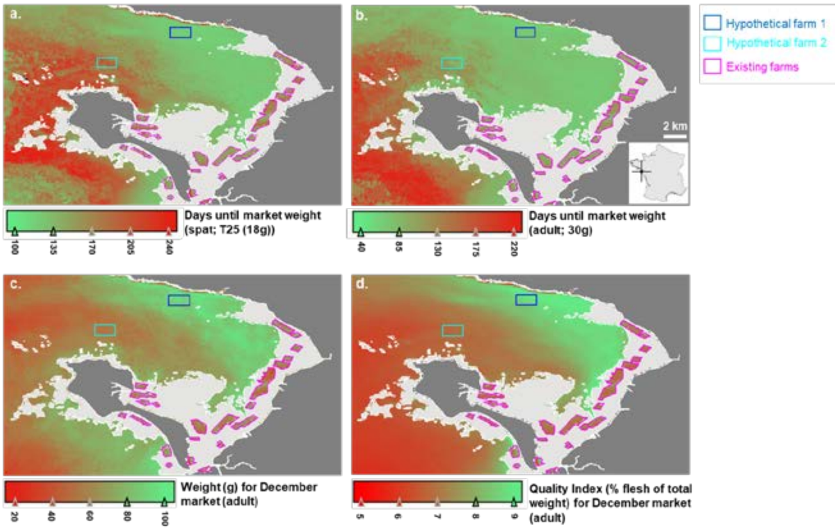

Figure 2.4. Maps of select oyster growth performance indicators for Bourgneuf Bay, with locations of existing farms in the intertidal zone, as well as those of the two hypothetical offshore farms compared in Figure 2.5 also indicated. (a) Days until T6-T8 spat reach target market size to sell to other producers (size T25; approximately 18g); (b) days until adult minimum market size (30g) is reached; (c) weight (g) obtained for the (main) December market; and (d) Quality Index (drained flesh weight/total weight (%)) obtained for the (main) December market. Maps are of the mean indicator values for the full nine-year time series.

Table 2.2. Selected oyster growth performance indicators for Bourgneuf Bay, for various production stages.

Production stage	**Indicator**
Spat	Time to reach T15 (6g); spring start
	Time to reach T15 (6g); summer start
	*Time to reach T25 (18g); spring start
	Time to reach T25 (18g); summer start
Adult/final year	*Time to reach minimum market weight (Calibre 5; 30 g)
	Time to reach Calibre 2 market weight (86-120g)
	Time to reach Calibre 3 market weight (65-85 g)
	Total weight in time for summer market (July 15th)
	*Total weight for end-of-season/December market (Dec. 6)
	Timing of spawn events
	Number of spawn events per year
Finishing/fattening	*Quality Index (% flesh weight/total weight) at end of fattening period

*Examples provided in Figures 2.4 and 2.5.

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Values of mapped indicators can then be used to quantitatively compare selected locations or regions of interest (ROIs). In Figure 2.4, the locations of existing farms in the intertidal zone are highlighted (in magenta colour), as are two hypothetical offshore farms (in light and dark blue) for comparison. The median and the variability of each, for each ROI, are presented in Figure 2.5, demonstrating how such maps can be used in site comparison and selection. In this case, although higher growth performance (i.e., target weights achieved earlier, and higher weights and Quality Indices achieved on target dates) than in the intertidal zone is possible offshore (e.g., the NNE sector of the bay; location of and surrounding the dark blue farm in Figs. 2.4, 2.5), it is clear that growth performance is highly variable offshore (e.g., much slower growth in the WSW sector where the light blue ROI is located (Figs. 2.4, 2.5), and that informed site selection, as possible through such spatially-explicit modelling, is important. Modelling output, such as the results presented here, provide a crucial biological component to be considered along with other environmental, social, technical, and economic factors, toward providing a realistic and holistic approach to site selection.

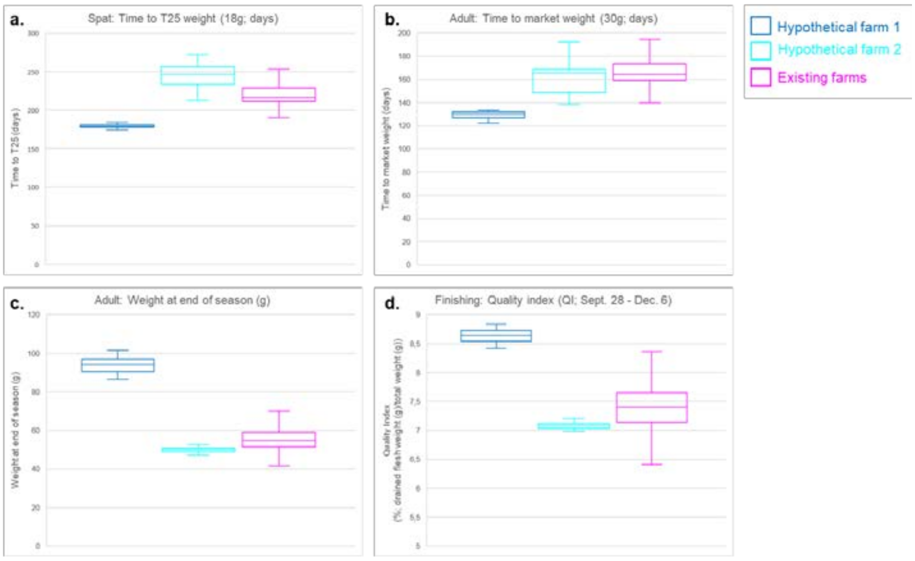

Figure 2.5. Values of select oyster growth performance indicators (as mapped in Fig. 2.4) for Bourgneuf Bay for two hypothetical offshore farms (dark and light blue) and existing farms in the intertidal zone (magenta). (a) Days until T6-T8 spat reach target market size to sell to other producers (size T25; approximately 18g); (b) days until adult minimum market size (30g) is reached; (c) weight (g) obtained for the (main) December market; and (d) Quality Index (drained flesh weight/total weight (%)) obtained for the (main) December market.

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2.4. Summary and evaluation of how this approach can be used to improve planning and management of shellfish aquaculture in Europe

The approach demonstrated here allows the identification of sites characterized by relatively favourable shellfish growth conditions. It is expected to be particularly useful in selecting new sites, whether as part of existing farming operations, by new farmers, or at the administrative level, when deciding which areas to allocate as available for farmers to lease, and is designed to be appropriate to the spatial scale at which such decisions are made. In the context of seeking to add new offshore production to the sector in Bourgneuf Bay, we have been able to compare oyster growth at existing, intertidal sites, with potential growth in the targeted offshore zone so that farmers and other industry stakeholders have *a priori* information on expected yields to consider in deciding whether to invest in such a direction, and, if so, where more specifically to optimally locate new farms.

In this case, the approach is applied for the Pacific oyster, *C. gigas*. However, the approach is equally adaptable to other species when *in situ* growth data are available for model calibration and validation, and has been used elsewhere applied to other species of interest to shellfish aqualculture, in France and internationally, such as blue and Mediterranean mussels (*M. edulis* and *M. galloprovincialis*; Thomas & Bacher, 2018) and great scallop (*Pecten maximus*; Le Goff et al. (2017)). Likewise, this approach can be applied anywhere that robust input datasets (i.e., food, temperature, and suspended particulate matter) are available, with model output validity dependent on the quality and validity of the input datasets. The input dataset has been calibrated and validated for the study site (Bourgneuf Bay) specifically, and, therefore, prior to applying a similar approach using satellite data to another site, Chl-a, TSM, and SST algorithm selection, calibration, and validation would need to be undertaken (e.g., Fig. 2.2). Where such data are available, the approach is broadly applicable.

Although this approach could also be applied where data are available for discrete points in space, it is considered to be particularly useful when spatialized, as done here using recurrent satellite-retrieved data as input. The current work uses higher spatial resolution input data than has previously been used, allowing corresponding higher spatial resolution model outputs, coherent with the farm-scale and therefore more applicable and relevant to the end-users considered. The output maps of growth over time can then be digested into related, higher-level indicators (e.g., weight thresholds and timings of interest, defined as part of this work in collaboration with local farmers), and can be used in Spatial Multi-Criteria Evaluation (Barillé et al. 2018) together with layers of other spatialized data that may influence whether production may be possible (e.g., bathymetry and distance from harbours, which determine feasibility) or how favourable be at a given site (e.g., presence of conflicting uses, such as fishing or tourism).

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3. Large scale offshore production of mussels in Lyme Bay, English Channel (Plymouth Marine Laboratory, PML)

3.1. Background

UK shellfish production is usually located in relatively shallow and sheltered coastal areas. However, in 2014, a large-scale mussel farm was established in Lyme Bay in the English Channel (Clarke and Bostock, 2017). The farm is operated by Offshore Shellfish Ltd (https://www.offshoreshellfish.com/) and uses rope cultured mussels offshore at low densities, a technique which is novel to the UK aquaculture industry but that is well established in other countries such as New Zealand.

The farm lease has an associated surface area of 15.4 km^2 split into three sites, two of 6 km^2 and one of 3.4 km^2 with the potential to produce up to 10,000 tonnes annually which is more than the total amount of mussels produced in Scotland at present (8200 tonnes in 2017 (Munro and Wallace, 2018)). The farm can be classified as an offshore shellfish aquaculture farm and the individual sites are located between 3 and 10km offshore. The farm has been increasing its overall production from a small test-pilot implementation in 2014 to the reported 1000 tonnes produced in the 2017. At the moment, the farm is being run at approximately 1/4 of its full capacity but further increases of production are expected to take place over the forthcoming years.

The work presented here is therefore timely and relevant to both the producer and the management authorities responsible for the evaluation of the impacts of the farm on the wider ecosystem. While monitoring efforts are being carried out as the farm increases its production through a collaboration between the University of Plymouth and Offshore Shellfish Ltd, work described here to better understand the potential consequences of full scale production could help improve the sustainable management of the farm.

3.2. Description of the modelling approach

The model domain covers the Lyme bay area situated in the South West of the UK from . Lyme bay is a large, open embayment on the south coast of England that stretches 65km of coastline from its western limit near Torcross in Devon to the Portland Bill lighthouse on the east in Dorset.

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The circulation in the bay is primarily driven by a combination of tides, wind and freshwater inputs. The tidal range at the four ports in Lyme Bay is moderate to large (3.4-4.4m) and the tidal streams dominate the patterns of water circulation except under significant extreme atmospheric conditions (strong winds and heavy rains). In order to resolve the interactions between the mussel farms and the environment one needs to take into account the 3D circulation, turbulence, the time evolving lower trophic ecosystem in the pelagic and benthic domains as well as animal-environment interactions involving the cultured mussels such as include ingestion (chlorophyll and non-chlorophyll organic particulates), biodeposition and excretion. In this context, the most common impacts that can be expected from intensive shellfish aquaculture production (detritus deposition, bottom anoxia, ammonium release, changes to benthic biodiversity and biomass) should be at least partially resolved by the modelling system. To that end, we have built a comprehensive model

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system coupling a hydrodynamic model, a sediment transport model, a biogeochemical model and a -shellfish growth model. The fully coupled system is capable of addressing most of these requirements and explore issues around carrying capacity in offshore shellfish aquaculture.

In order the resolve the small-scale interactions at the farm level, we need to have a model resolution that accounts for environmental interrelations dependent upon the spatial configuration of the farm within the environmental variability. For our test case, this means resolving sub-km scale dynamics. To that end, we have setup a nested modelling approach of increasing model resolution. The atmospheric forcing is provided by a 3 step downscaling of GFS global datasets using the weather-research-and-forecasting (WRF) model to reach the 3km of the final model domain. For the coupled hydrodynamic-biogeochemical model we use a parent domain of 1.5 km-10 km resolution (Figure 1) to drive our 350m-5km high-resolution Lyme bay model domain (Figure 5).

3.2.1 Hydrodynamic model

The model used in this study is the Finite Volume Coastal Ocean Model (FVCOM, Chen et al., 2003), a prognostic, unstructured-grid, finite-volume, free-surface, 3D primitive equation coastal ocean circulation model . FVCOM solves the 3D momentum, continuity, temperature, salinity, and density equations by computing fluxes between unstructured triangular elements. Vertical turbulent mixing is modelled with the General Ocean Turbulence Model (GOTM) using a k-ϵ formulation (Umlauf and Burchard 2005) whilst horizontal mixing is parameterised through the Smagorinsky scheme (Smagorinsky 1963) with a coefficient of 0.1. The vertical grid in FVCOM is described in terrain following (sigma) coordinates (24 levels) where shallower areas resolve vertical structure with finer detail.

FVCOM has been widely used in shelf and coastal domains for a range of problems where a strong need exists to resolve varying horizontal scales, including: physical modelling of temperature and salinity stratification (Chen et al., 2007; Yang and Khangaonkar, 2008; Zheng and Weisberg, 2012); modelling impacts from marine renewable energy devices (Cazenave et al., 2015); tracer evolution in complex estuaries (Torres and Uncles, 2011); the behaviour of sequestered CO_2 leak plumes (Blackford et al., 2013); tracking the dispersal of lice Adams et al. (2012, 2014) and aquaculture (Foreman et al., 2015).

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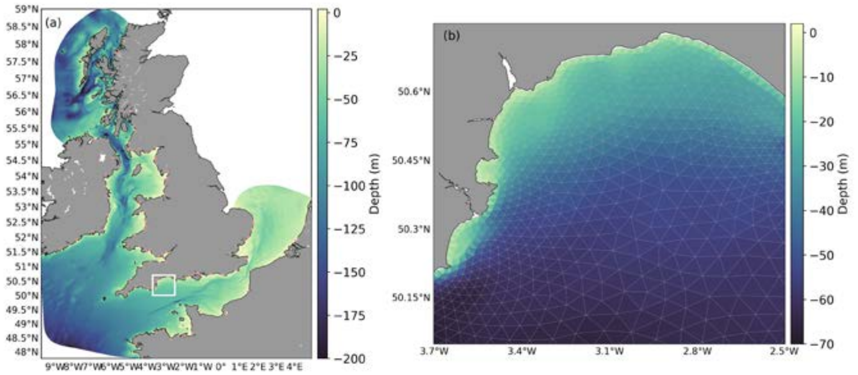

Figure 1 a) Bathymetry of parent model domain and location of rivers flowing into the domain. b) Detail of the mesh in the Lyme Bay area covered by the high resolution model implementation.

The hydrodynamic model FVCOM, the biogeochemical model ERSEM) and the shellfish aquaculture model ShellSIM (3.2.3. ShellSim) are coupled through FABM (Framework for Aquatic Biogeochemical Models; http://fabm.net) (Bruggeman and Bolding, 2014). FABM is a domain-independent programming framework with support for any number of processes, prognostic variables, diagnostic variables, and advanced features such as surface- and bottom layers (sea ice biota, benthos, sediment, aquaculture practices) and multiple feedbacks to physics. FABM runs as part of its "host model", in this case FVCOM. In a coupled FVCOM-FABM simulation, the final executable program remains FVCOM, which incorporates FABM and accesses it through the FVCOM-FABM coupler. The use of FABM enables the definition of two-way feedback processes between ShellSIM and ERSEM to be defined at run-time.

3.2.2. Sediment transport model

The sediment transport model is the finite volume implementation of the Community Sediment Transport Model described in Warner et al. (2008). Previous implementations of the same model in the area were done with the Regional Ocean Model System (ROMS, Guillou et al., 2015; Guillou and Chapalain, 2010). The authors modelled the entire of the Western Channel while we are concentrating on Lyme bay. While their setup included 4 sediment classes (silts, 25 µm, very fine sands, 75 µm, fine sands 150 µm and medium sands 350 µm), Lyme bay sediments are mostly composed of very fine and fine sands. Because of the shallow location (25m) of the mussel farm under study we consider the dynamics of Suspended Particulate Matter (SPM) to be of importance. In order to reproduce the observed surface SPM as reported in Guillou et al. (2015) and evident in more recent EO observations, we used 3 sediment types as described in Table 1. Only two of the sediments are subject to remobilisation and transport and the third "Immobile" class represent bare substratum.

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Table 1. Main characteristics of the 3 sediment classes used in the present simulations.

SPM type	Diameter (μm)	Vertical settling velocity mm s^{-1}	Critical shear stress N m^{-2}
Silt	50	0.3	0.15
Fine Sands	150	0.6	0.25
Immobile	30000	15	6.5

3.2.3. Biogeochemical model

The biogeochemical model used is ERSEM (Baretta et al., 1995; Blackford et al., 2004; Butenschön et al., 2016). ERSEM is a biomass and functional group -based biogeochemical model describing the nutrient and carbon cycle within the low trophic levels of the marine ecosystem (Figure 2). Model state variables include living organisms, dissolved nutrients, organic detritus, oxygen and CO2. Pelagic living organisms are subdivided in three functional groups describing the planktonic trophic chain: primary producers (phytoplankton), consumers (zooplankton) and decomposers (bacteria). Primary producers and consumers are subdivided into 4 and 3 size-based functional types, respectively. The phytoplankton community is composed of picophytoplankton, nanoflagellates, dinoflagellates and diatoms, while the zooplankton community is composed of mesozooplankton, microzooplankton and heterotrophic nanoflagellates. Decomposers are modelled by one type of heterotrophic bacteria. Functional types belonging to the same group share common process descriptions but different parameterizations.

A key feature of ERSEM is the decoupling between carbon and nutrient dynamics allowing the simulation of variable stoichiometry within the modelled organisms. Chlorophyll is also treated as an independent state variable following the formulation by Geider et al. (1997). Consequently, each plankton functional type is modelled with up to five state variables describing the cellular content of carbon, nitrogen, phosphorus, silicon, and chlorophyll-a. Dissolved organic matter (DOM) is produced by different processes involving phytoplankton, bacteria and zooplankton while its consumption is exclusively regulated by bacteria uptake. DOM is subdivided into labile, semi-labile and semi-refractory components (Polimene et al., 2006), in order to provide a representation of the range of organic compounds present in the marine DOM and their different levels of degradability. Particulate organic matter (POM) is produced by phytoplankton and zooplankton and it is divided into three size-based categories corresponding to different sedimentation rates.

All the ERSEM equations are detailed in Butenschön et al. (2016) and we refer the reader to that paper for a comprehensive description of the mathematical formulations used in the model.

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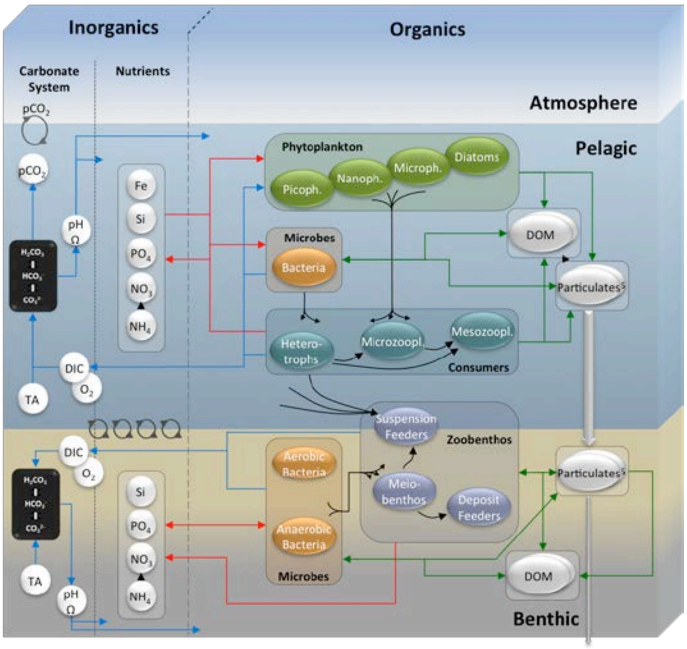

Figure 2 Schematic of ERSEM structure, links and processes in a typical configuration

3.2.3. ShellSim model

Filter-feeding bivalve shellfish are highly responsive to their variable environments. Dynamic simulations are therefore required to account for the associated complexity of animal-environment interrelations. There has been a long-standing need to simulate relevant functional dependencies, towards a common model structure which may be calibrated for different species and circumstances. The solution pioneered by PML has been ShellSIM (Hawkins et al., 2013a; http://www.shellsim.com), a dynamic model structure whereby a minimal set of environmental drivers affect feeding, metabolism and growth, including dependencies between those component processes of growth, drawing upon physiological principles of energy balance (Hawkins et al., 2013a) (Figure 3).

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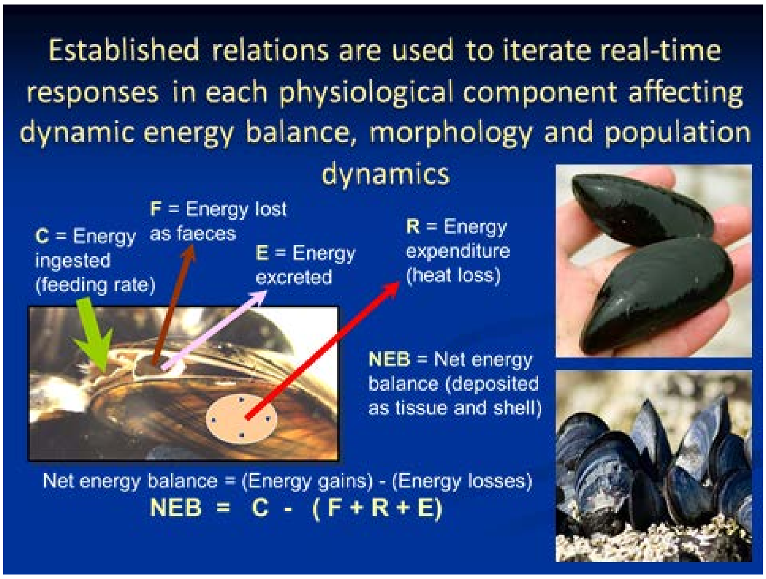

Figure 3 Physiological components of net energy balance predicted by ShellSIM

The environmental drivers used by ShellSIM, known as ”forcing functions”, are summarized together with simulated responses in Figure 4. Notable novel elements of ShellSIM include resolving rapid regulatory adjustments in the relative processing of living chlorophyll-rich phytoplankton organics, non-phytoplankton organics and remaining inorganic matter during both differential retention on the gill and selective pre-ingestive rejection within pseudofaeces. This is important, for shellfish may obtain significant energy from both living chlorophyll-rich phytoplankton organics and the remaining organics such as may include detritus, bacteria, protozoans and/or colloids, when the relative abundances of different dietary components varies greatly between sites (Hawkins et al 2013b). Largely by virtue of having resolved the relative processing of living chlorophyll-rich phytoplankton organics from remaining organics, then applying a single standard set of parameters optimized per species, ShellSIM has proven able to simulate growth to < 20% error in each of *Mytilus edulis, Crassostrea gigas* and *C. virginica* across wide ranges of environment and culture practice throughout Europe and Asia (Hawkins et al., 2013a). Compared with previous models, this has been an important advance, saving time and resources during application in new projects. Simpler models have neither been able to predict successfully across contrasting environments, nor able to simulate responsive adjustments in feeding and metabolism, thus providing little insight into the dynamic manner whereby suspension-feeding shellfish interact with ecosystem processes, including environmental effects such as the volume of water cleared of particles, biodeposition, oxygen uptake and nitrogen losses.

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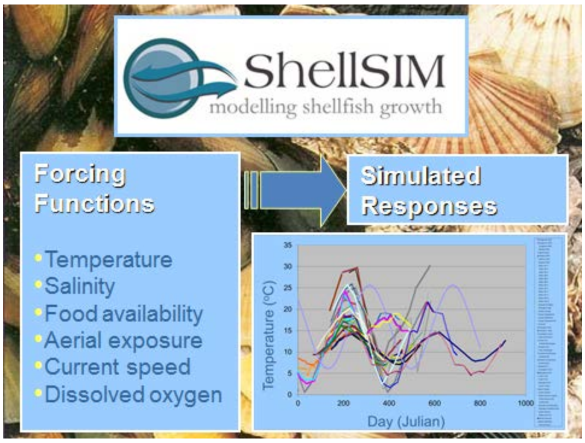

Figure 4 Forcing functions used by ShellSIM.

Given that the farm in Lyme bay grows only Blue mussels (*Mytilus edulis*), we run ShellSIM using only parameters valid for that species. Outside of the farm areas, all ShellSIM variables are initialised to 0 and the model is not run. The dynamics of the individuals and population are captured by the set of variables described in Table 2. The ERSEM variables that the mussel model consume are all four phytoplankton groups (picophytoplankton, nanoflagellates, dinoflagellates and diatoms), two heterotrophic groups (microzooplankton and heterotrophic nanoflagellates) as well as the largest detritus pool. The mussels also interact with the oxygen, CO2 and ammonia pools in ERSEM. Pseudofaeces and faeces, when excreted, are incorporated into the ERSEM large detritus variable.

Table 2 List of ShellSim variables in the Blue Mussel (*Mytilus edulis*) model

Short name	Long name	Units
BM_C1	Blue Mussels individuals per cubic meter in the class C1	ind m^{-3}
BM_C2	Blue Mussels individuals per cubic meter in the class C2	ind m^{-3}
BM_C3	Blue Mussels individuals per cubic meter in the class C3	ind m^{-3}
BM_DSTW	Blue Mussels Dry Weight of the Soft Tissue	g⁄ind
BM_DShW	Blue Mussels Dry Weight of the Shell	g⁄ind
BM_STEn	Blue Mussels Energy of the Soft Tissue	Jules⁄ind
BM_ShEn	Blue Mussels Energy of the Shell	Jules⁄ind
BM_aging	Blue Mussels Aging effect	-
BM_c	Blue Mussels specific C content	mgC /m3
BM_cshell	Blue Mussels specific C content in the shell	mgC /m3
BM_n	Blue Mussels specific N content	mmolN /m3
BM_nshell	Blue Mussels specific N content in the shell	mmolN /m3

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BM_p	Blue Mussels specific P content	mmolP /m3
BM_pshell	Blue Mussels specific P content in the shell	mmolP /m3

3.2.4. Regional settings and model setup approach

The model domain covers the Lyme bay area, situated in the South West of the UK and extending from -3.75 W, 50.06N to -2.54 W, 50.73N. There are four main rivers included in the domain, the Exe, the Teign, the Dart and the Brit. Characteristic river flows for each river are presented in Table 3.

Grid configuration

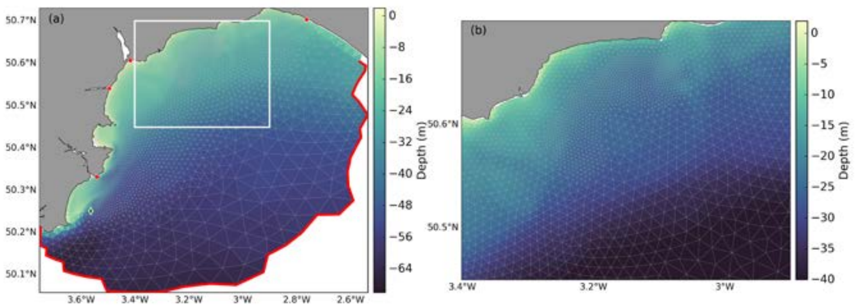

Figure 5 The model domain and bathymetry (a) and zoom subset (b). Red circles indicate the position of freshwater sources. The red line corresponds to the common set of nodes with the parent model that ensures volume and mass conservation at the boundaries.

The model domain (Figure 5a) is defined by the initial coastline sampled at resolutions of 700m. The model grid is constructed such that the resolution in the interior is controlled by the water depth, bathymetry gradient, coastline curvature and coastline resolution using a size function to build spatially varying element sizes to satisfy the hydrodynamic requirements. Final manual adjustment of the grid ensures the quality criteria in the FVCOM manual (Chen et al. 2013) are met. The final model grid contains 7996 elements constructed from 4136 nodes; element sizes range in size from 3500m at the open boundaries to 350m along parts of the area where the mussel farm is in operation (Figure 5b). The vertical discretisation of the water column uses a sigma level distribution of 24 vertical levels.

Water depth within the model domain uses the EMODNET bathymetry product with a nominal resolution of 1/16 deg. The final water depths for each grid node are calculated by linearly interpolating the scatter data onto the mesh nodal positions. The bed roughness length (z_0) was calculated as a function of the distribution of bed D50 within the domain from the shelf-wide sediment distribution data from the British Geological Survey (BGS).

The surface area of the domain is 4339 km^2 with an average volume of 193 km^3.

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Open boundaries

The model implementation is forced by outputs generated from a parent FVCOM implementation of the South and Western UK shelves (Figure 1). The data along the boundaries were generated at 15-minute intervals and include surface elevation, depth varying and depth averaged currents, temperature and salinity profiles and all ERSEM pelagic state variables. The model domain is initialised with temperature and salinity fields interpolated onto the FVCOM grid from the UK shelf implementation of NEMO as provided by CMEMS on 01/01/2005. The model was started from rest (zero velocity and surface elevation) and ramp up during seven days to allow the velocity and turbulence fields to stabilise.

For the parent domain simulations, the full set of ERSEM variables as daily averages were obtained from custom simulations with the UK shelf NEMO grid (identical to the one used in the operational CMEMS service). The ERSEM setup used was that created by the UK program Shelf Seas Biogeochemistry (SSB) funded by NERC. For the hydrodynamic variables we used a combination of CMEMS North-West European Shelf hourly data for non-tidal variables and TPXO tidal surface elevation time series as 10 minute intervals from the TPXO Tidal Model Driver (TMD) MATLAB toolbox (Egbert et al., 1994) using the OSU Tidal Inversion Software (OTIS) European regional tidal solution (Egbert et al., 2010).

Surface forcing

The atmospheric forcing consisting of all necessary fluxes such as heat flux, wind, evaporation and precipitation at the model sea surface were generated with a Weather Regional Forecasting **(**WRF) setup with a resolution of 3 km with a 3 hourly frequency. The atmospheric model is initialised with the global atmospheric forecasts from the United States national Weather Service (NWS) GFS and run in a 3 nested configuration of increasing resolution from 20km to the final 3km. The model is configured to run a 6 hour of spin-up and 24 hours of simulation to avoid large deviations from the true state. Each 24 hour model simulation is then consolidated into monthly forcing files.

Freshwater input

The model includes 4 locations of freshwater inputs at discrete locations along the model coastline (red dots in Figure 5a).

River flows are predicted from integrated river catchment precipitation and mean air temperature from our Weather Regional Forecasting (WRF) simulations using a dense layer neural network model. The python Keras package is used to implement the neural network and a lagged history of up to a week for temperature and up to a month for precipitation are used as inputs. The networks are trained on 10 years of river flow gauge data from the National River Flow Archive. River temperature is predicted using a multiple linear regression model based on mean catchment air temperatures for the past three days. The regression is based on temperature observations from the Environment Agency river monitoring database and includes observation height as a proxy for upriver distance.

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Concentrations of nutrients, oxygen, dissolved inorganic carbon (DIC) and fine sediments concentrations were obtained from simulations by the Center of Ecology and Hydrology (CEH) of their LTLS model that provides monthly concentrations for all coastal points in their 5x5km grid.

Of the four main rivers that flow into Lyme Bay, the Exe is the main contributor (Table 3), with a net yearly flow two to four times each of the other rivers (Dart, Teign and Brit).

Table 3 River yearly inputs into Lyme bay. Flow and biochemical variables are scaled by 109. Fine sediments are scaled by 106

River name	year	flow (m3)	NO_3 (molN)	NH_4 (molN)	PO_4 (molP)	SiO_2 (molSi)	O_2 (molO)	DIC (molC)	fine seds (Kg)
Dart	2005	0.32	62.54	5.78	1.03	52.46	110.42	661.47	2.85
Dart	2006	0.35	66.88	5.58	1.13	57.03	120.35	717.56	3.40
Teign	2005	0.27	75.47	9.09	0.88	46.33	87.45	541.49	3.22
Teign	2006	0.27	75.65	9.00	0.98	47.75	89.73	555.76	3.54
Exe	2005	0.77	250.91	27.50	3.63	135.29	260.40	1562.80	9.69
Exe	2006	0.80	246.85	27.43	4.11	139.87	270.87	1628.54	10.38
Brit	2005	0.20	68.80	27.75	1.34	35.16	56.84	414.47	3.75
Brit	2006	0.20	67.36	28.05	1.54	35.39	58.13	416.62	3.85

Mussel farm configuration

In our approach to simulating the potential mussel production in Lyme Bay we have made some assumptions and practical decisions with respect to the physical setup and management of the farm. The seed density, seed size, and geometric disposition of the ropes have been defined by us with the aim of reproducing the total projected production of the fully develop farm. The general validity of our assumptions have been checked with the operators of the farm, however no real data on cultural practices have been used in order to protect the sensitive commercial information of the enterprise. Since the model doesn't resolve individual growing ropes, such approximation does not affect the results of the present work.

We have assumed that the initial density of the spat on the rope is 200 ind m^{-1}. This assumption is based on the following considerations regarding morphology and productivity of the farm operating in Lyme bay and managed by Offshore Shellfish Ltd. In 2017 the farm was operating 150 headlines of the 790 that were originally granted with the permit. The harvest associated with the current operation was of 1000 Tonnes which implies a final mussel density of about 150 individuals per meter of rope. The surface area of the operating farm is approximately ~ 6 km^2. We have assumed a configuration such that each headline (220m long) has associated approximately 200 vertical ropes with mussels. With such a configuration each rope will, at the time of harvest, hold roughly 50-60kg. With 790 headlines in operation, the projected annual production is ~10,000 Tonnes. The farm is located in areas with depths ranging from 20 to 25 m. On 25m, the seed are placed on 10m rope sections that hang from 3m below the surface. The model areas associated with the leased space correspond to ~ 23 km^2. Assuming a total number of ropes of 173800, the average rope density in the farms is 0.0076 ropes /m^2. The farm in operation is located in an area where the mesh has a nominal resolution of ~ 350 m (Figure 5) and a mean surface area for each control volume of 0.1 km^2

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so that we can expect 1000 ropes per model element. The three farms (west to east) have a model associated surface area of 8.85, 8.2 and 5.7 km^2 respectively.

With 6 kg m^{-1} of final production on each rope, assuming a market mussel weight of 30g, we need an individual density of 200 individuals m^{-1}. We have run all our simulations with an initial spat seed density of exactly 200 ind m^{-1} of rope.

In reality, ropes can have much higher density to account for losses due to handling of the ropes, environmental agitation from storms and predation, none of which are processes are included in the model. Because of the coarse resolution of the model in the farms, the model area associated with the farms is larger than the actual leased area. Similarly, our rope density is also smaller than that can be expected from the developed sites.

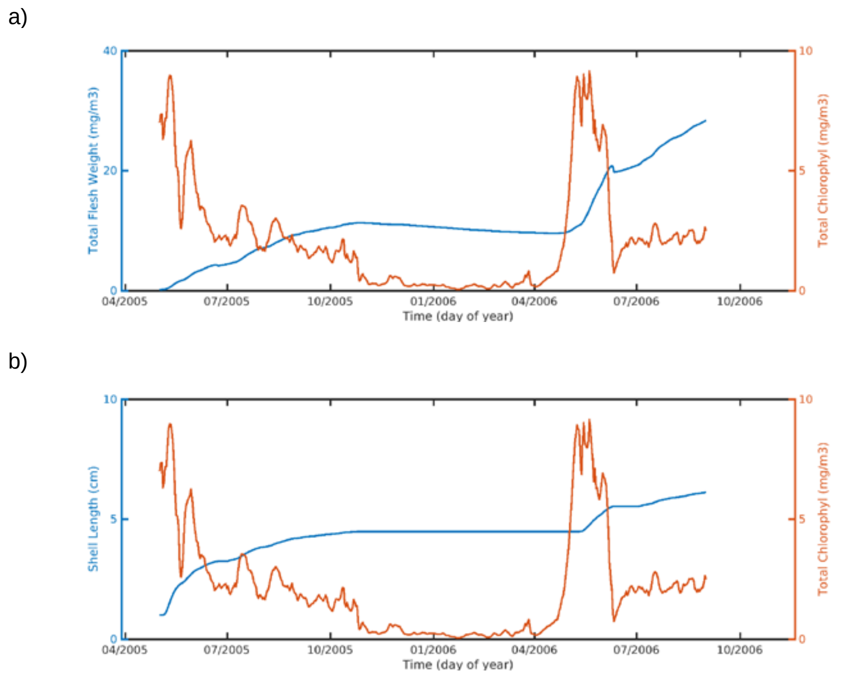

Figure 6 Time evolution of the median total chlorophyll-a (red) in the central farm integrated over the water column and 10 random model nodes in the central farm and the characteristic total fresh weight of individual blue mussels (a) and the shell length (b) (blue) in those same model nodes during one growing cycle.

In the simulations discussed here, the seed are placed from 1st May in the 3 farm configuration, about one week into the spring bloom in 2005 (Figure 6a).

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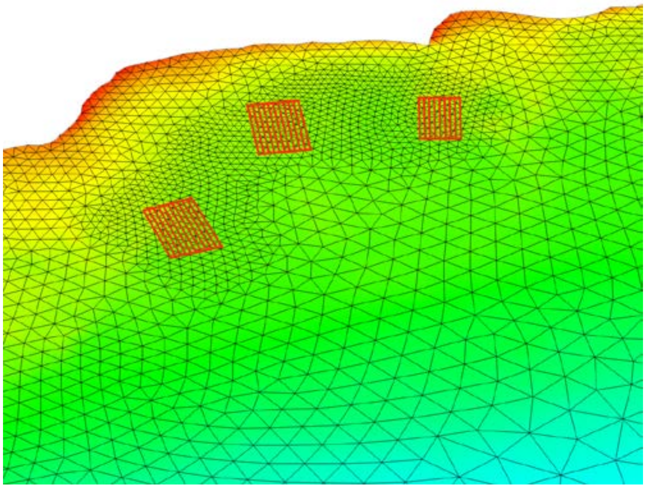

Figure 7 Zoom of the model mesh and bathymetry overlaid with the lines of hanging ropes that are associated with the permit for Offshore Shellfish Ltd. aquaculture activities in Lyme Bay.

Initial model tests indicate that blue mussels in this area can achieve a market size of 25g and 6 cm in about 13 months when grown from seed of 10mm long (Figure 6). The growth pattern reproduced by ShellSIM suggests that the mussels grow monotonically during the initial spring bloom and summer while growth stalls during the winter period due to insufficient food. The second spring bloom supports exponential growth and the mussels reach a marketable size (e.g. 25g and 6cm of shell length) in early summer.

3.3. Model output

3.3.4. Validation

The model results have been validated against sea surface temperature (SST) from Advanced Very High Resolution Radiometer (AVHRR) Level 3 (L3) Earth Observation (EO) data (2005-2009) provided by PML NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS), in-situ CTD and water sample observations from the ICES dataset (2005-20027) and with temperature records of 4 buoys operated in the area by the Channel Coastal Observatory (https://www.channelcoast.org) (2008-2009). More extensive validation of the parent model including HF Radar and ADCP records has also been reported in Cazenave et al (2015).

Sea surface temperature

The model sea surface temperature (SST) has been compared against EO SST estimates and surface temperature records from 4 coastal buoys (Figure 8)

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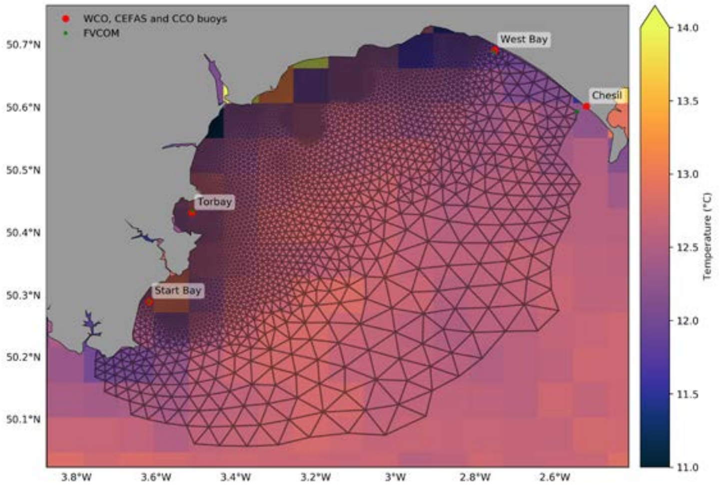

Figure 8 Map of the model grid showing the location of the buoys used in the model validation overlain on the annual averaged of SST AVHRR observations for the year 2005.

The buoy records for 2008 (Figure 9) indicate the model performs well during the mixed periods (January-May and October-December) while the model displays cooler surface temperatures during the stratified periods (June-September). This is a consistent picture which is also reproduced in 2009 (not shown) and in the EO-model comparisons (Figure 10). Mean monthly correlations for the 2005-2009 period oscillate between 0.7 and 0.9 when the months are restricted to those showing more than 50% data presence. Typical mean biases range between -1.8 ºC and 0.5 ºC with an overall mean of -0.1 ºC. The mean root mean square error for all months analysed is 0.7.

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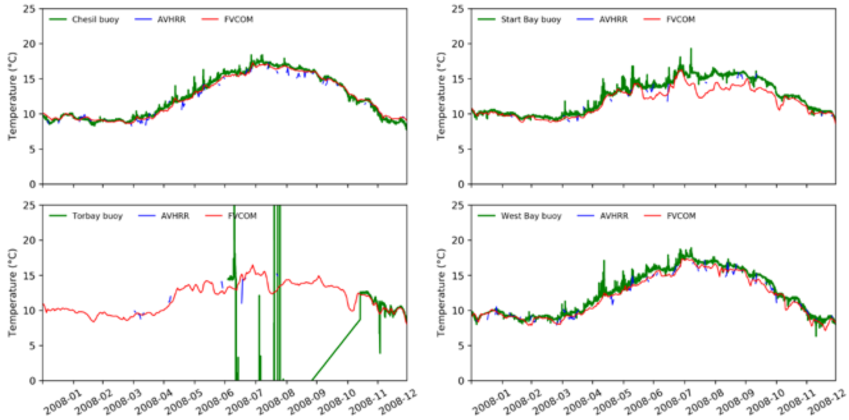

Figure 9 Comparison between hourly surface temperature records from the four coastal buoys within Lyme Bay, daily median composites of SST AVHRR observations at the same position and the shallowest daily mean model temperature.

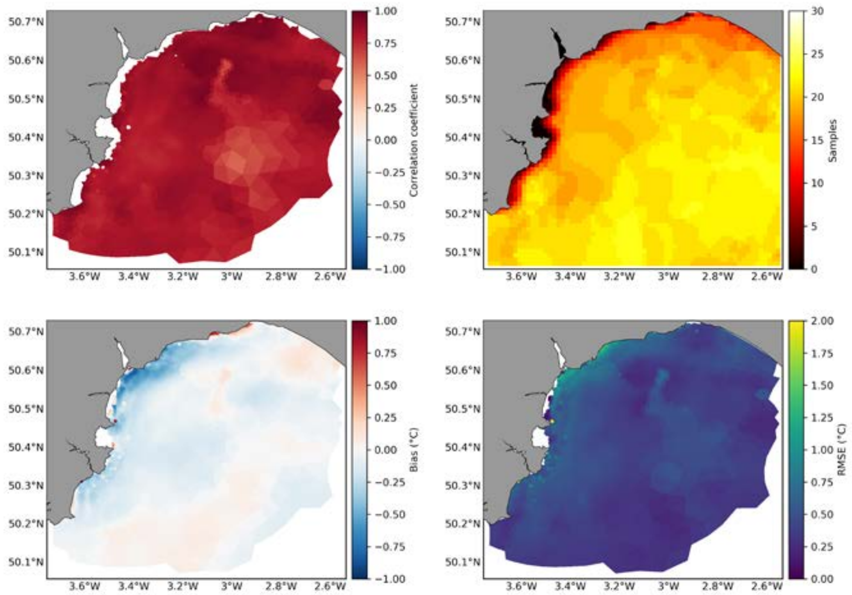

Figure 10 Example SST validation for March 2007. The AVHRR data are daily composites at 1km resolution interpolated to the FVCOM grid using nearest neighbour interpolation. From top left clockwise we have the Pearson correlation coefficient, number of samples in the month, mean bias and the root mean square error.

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Biogeochemical variables

The small number of in-situ observations available during the simulation period in the Lyme Bay domain prevents doing a statistically significant comparison. Because there are no differences in atmospheric forcing, riverine forcing and biogeochemical model structure and parameterisation between the parent domain (Figure 1) and the high resolution domain (Figure 5) we show here the validation results using the parent model domain results. Overall, the model was able to reproduce the seasonality at a selection of coastal sites (e.g. Carlingford, Northern Ireland, Figure 11) for surface chlorophyll-a and total particulate organic carbon (POC). The model POC includes both living plankton (phytoplankton, microzooplankton and heterotrophic flagellates) as well as detritus in accordance to the way the observations were taken. It is worth noting the model does under-predict POC concentration in winter.

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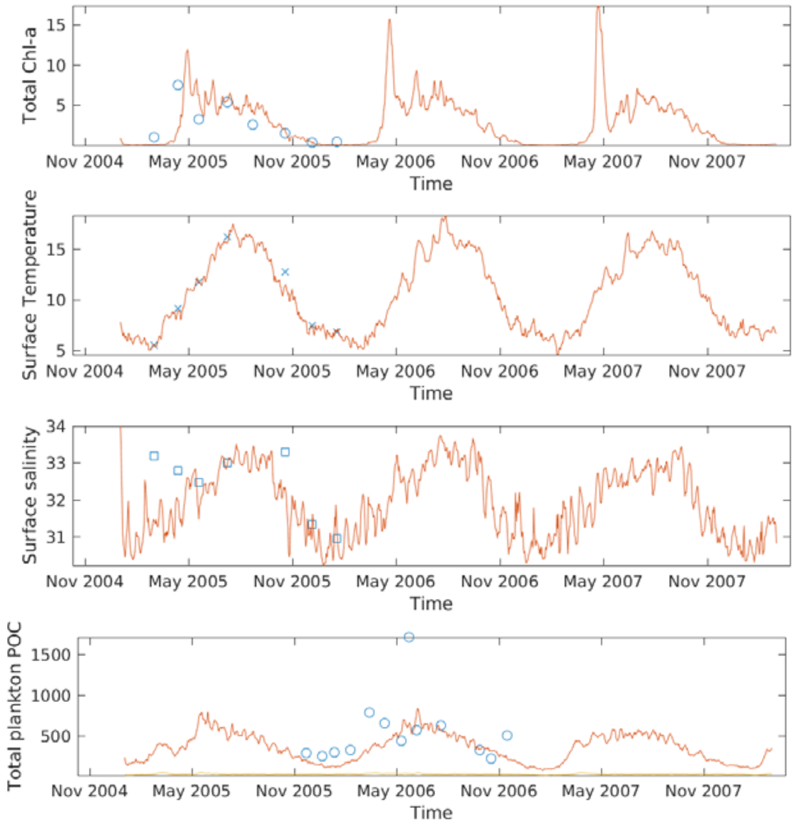

Figure 11 Example of model -observation comparison for a coastal site in Carlingford within the parent model. These data were collected during the SMILE project (Ferreira et al. 2008) for the original calibration of ShellSIM (Hawkins et al. 2013a, b).

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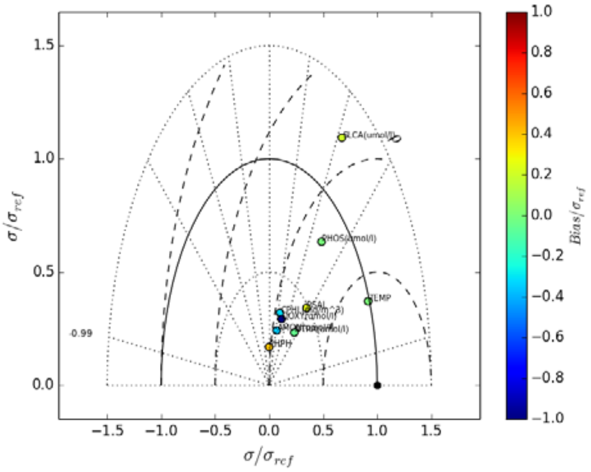

Figure 12 Taylor diagram of Parent model validation against ICES CTD data for 2005-2007. The spatial distribution of the data is concentrated around the English Channel, Iris Sea and West Scotland.

A more substantial validation was performed with data from the publicly available from the International Council for the Exploration of the Sea (ICES) EcosystemData Online Warehouse (ICES, 2009). A total of 18000 data points were used in the temperature and salinity comparison and include surface as well as surface observations. The Taylor diagram (Figure 12) and Table 4 summarise the results. It is worth noting that most of the biogeochemical observations (Figure 13) correspond to shallow coastal areas where tides have a large influence and we are comparing daily averaged model results. Similarly, the scales of variability near the coast are smaller than the model resolution which penalises one to one statistical comparisons (de Mora et al, 2013). The overall picture is that the model resolves well the temperature dynamics, does an acceptable job at simulating the salinity and macronutrients distribution and displays a correlation with chlorophyll-a which is within the ranges reported by other implementations of ERSEM in the UK shelves (e.g. de Mora et al, 2013). It is worth noting that our correlations are always higher than those reported in de Mora et al., (2013) despite the shorter time range used in the comparison (4 vs. 46 years).

Table 4 Correlation values for the ICES-model comparison for years 2005-2008

O_2(µmol/l)	0.365
NO_3 (µmol/l)	0.709
SO_4(µmol/l)	0.524
PO_4(µmol/l)	0.608
Temperature (C)	0.927
NH_4(µmol/l)	0.278
Cholorophyll-a(mg/m^3)	0.299
Salinity	0.711

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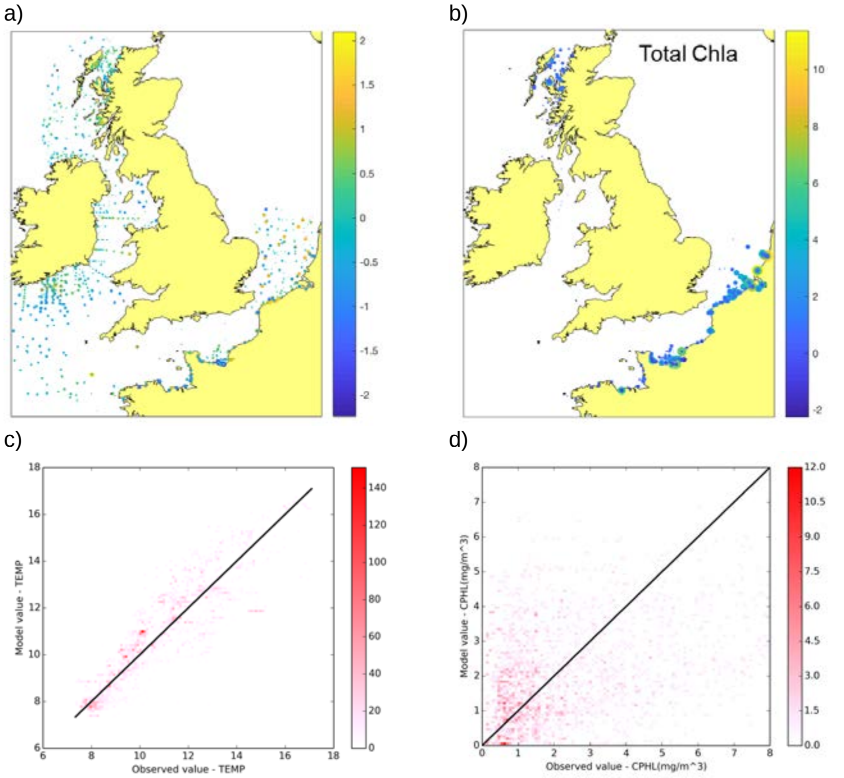

Figure 13 Examples of the one-to-one model-data comparison between the parent model simulations and the ICES dataset for years 2005-2008. The top panels show the spatial distribution of the data used for a) temperature and b) chlorophyll-a. The temperature records include some 18000 data points and spans the full data column. The size and color of the dots in a) and b) represent the bias between the observation and the matched model result. The one to one scatter plots for c) temperature and d) chlorophyll-a are color-coded with the number of samples in each binned category.

The parameters that are included in ShellSIM for *Mitylus edulis* have been calibrated using observations of shell length and total flesh weight in previous studies (Hawkins et al., 2013b). Here, we compared the observed shell length with the model results in two locations (Carlingford and Belfast, both were part of the original calibration effort) when ShellSIM is driven by the observations used in the original calibration and when driven with outputs extracted from the FVCOM-ERSEM parent model system (Figure 14). The results indicate that FVCOM-ERSEM outputs are sufficient to qualitatively reproduce the observations and that in some instances the fit to observations is better than when measures are used to drive ShellSIM. This suggests there is no requirement to re-parameterise ShellSIM to work with FVCOM-ERSEM outputs.

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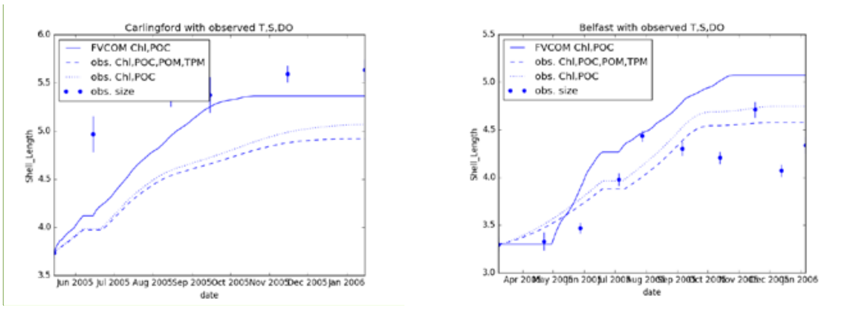

Figure 14 Comparison between observed and modelled shell length under different ShellSIM setup configurations.

Commented [RT8]: Yuri any chance of re-doing these graphs with better labelling?

3.3.5. Suitability assessment

When considering offshore mussel shellfish aquaculture production, the main characteristics of interest for a potential site (ignoring logistical aspects such as access to shore facilities, processing facilities and distribution networks) are the predictable availability of food, the dispersive or non-retentive character of the site and a low level of stratification to avoid sharp vertical gradients that in rope aquaculture practices could imply differential food availability and non-homogeneous production. This information is extracted from a model simulation covering 2005-2009 with no aquaculture operation. Therefore, this simulation can be considered to represent the baseline conditions of the region.

The spatial (Figure 15) and temporal (Figure 16) distribution of the available resources for mussel growth in Lyme Bay indicates that the present lease location is an appropriate location in the bay. The distribution of the time averaged daily means of all carbon pool concentrations that support mussel growth at the top of the mussel ropes suggests a general increase in food availability towards the coast and north east area of the domain (Figure 15). The figure indicates that the farm is situated on a suitable location when balancing water column depth and food availability. The area also shows low SPM concentrations despite the shallow depths and proximity to the Exe estuary (Figure 17). This is primarily a consequence of the sea-bed being mainly composed of gravel-sand sediments that are not readily resuspensible by the characteristic tidal currents experienced in the area. The weak stratification experienced in the farm area (Figure 18), a consequence again of the shallow depths and strong tidal currents, contributes to favourable mussel production conditions by ensuring the vertical distribution of food is as homogeneous as possible.

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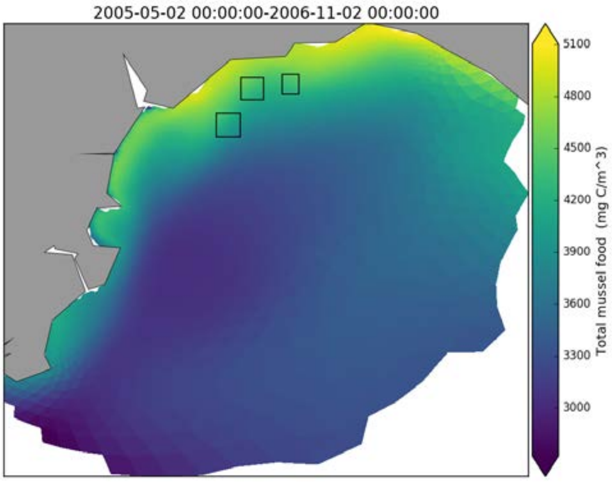

Figure 15 Spatial distribution of the averaged mussel food (in terms of carbon) availability for the growing season of 2005-2006. These include the live phytoplankton resources as well as the living non-chlorophyll resources (microzooplankton) and detritus pools.

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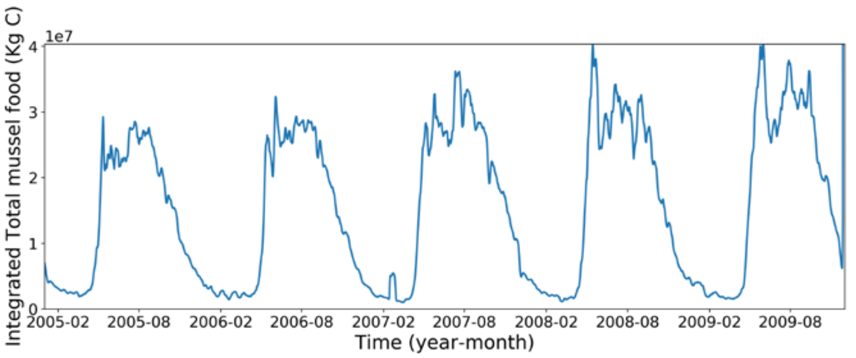

Figure 16 Time evolution of the domain and depth integrated of organic particulates that are consumed by the mussels over the five year long simulation. This showcases the interannual variability experienced in the area. Both the maxima and widths of the peaks change year on year.

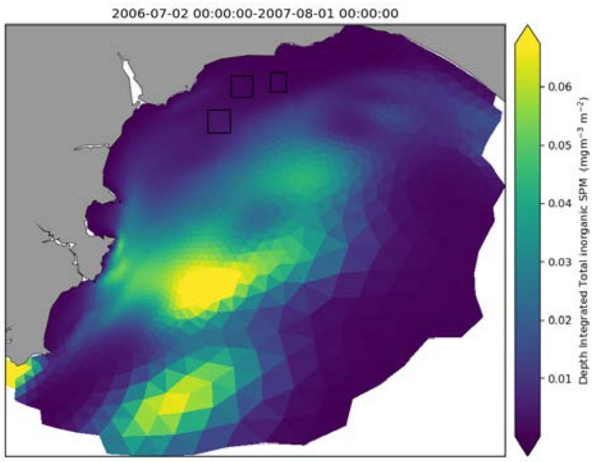

Figure 17 Integrated mean SPM concentrations over 12 months spanning July 2006 to July 2007

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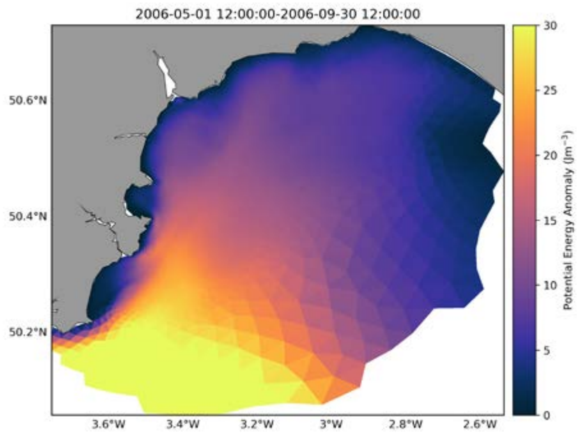

Figure 18 Average Potential Energy Anomaly between May and September 2006 showing typical summer stratification spatial patterns.

3.3.6. Farm production scenario

The production scenario developed by Offshore Shellfish Ltd under the operation of all leased area is of the order of 10,000 Tonnes/year. Our approximated configuration to their operation's setup suggests that the farms can reach their estimated production in 13 months (Figure 19) when the spat is placed in the water in May, during the peak of the spring bloom.

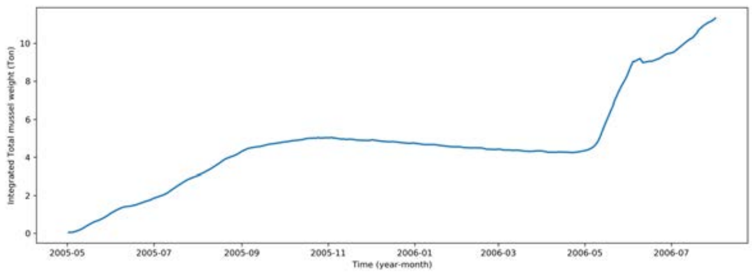

Figure 19 Time evolution of the total flesh mussel weight (in 1000s of Tonnes) for all 3 farms operating at full capacity.

Our model results also indicate a level of heterogeneity in the final mussel flesh weight distribution with the central farm showing the largest production, followed by the westernmost farm. The easternmost farm shows the least production of all 3 farms.

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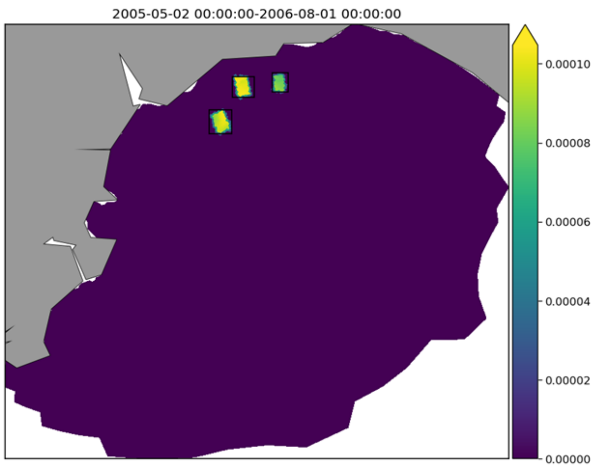

Figure 20 Depth integrated mussel weight (Kg/m) at the end of one growing season (May 2005 until July 2006) showing the final differences in potential production between the 3 farms.

3.3.7. Farm-ecosystem interactions

Commented [RT9]: Could be moved to 3.4 section

Commented [LF10R9]: I think it is ok here

The effects of operation at full capacity for all 3 farms can be evaluated in multiple ways considering many aspects of the functioning of this coastal ecosystem. It is generally accepted that the main areas of interaction between mussel aquaculture and the environment are around the export of particulate organic matter to the bottom, changes in sediment and bottom oxygen concentrations and changes to plankton concentration. All these metrics are readily calculated in our model setup and are presented next. This list is not exhaustive and we will be exploring other metrics that encapsulate broader ecosystem metabolic functions such as net primary production and community respiration.

Our approach has been to calculate the changes between a simulation without any aquaculture production (baseline simulation) and an exact replicate of the setup except for the presence of rope aquaculture of mussels. The results are presented in two forms: as an anomaly-ratio and as the number of days the difference between the two simulations is higher than a specified threshold (here set as a 5% change with respect to the baseline simulation). The anomaly-ratio that for each metric under consideration X is defined as

$$X_{Ar} = \frac{X_{aquaculture} - X_{baseline}}{X_{baseline}},$$

For the anomaly-ratio figures, we include two contours corresponding to the 1 and 5% change in conditions with respect to the baseline simulation (solid lines for an increase under the farm

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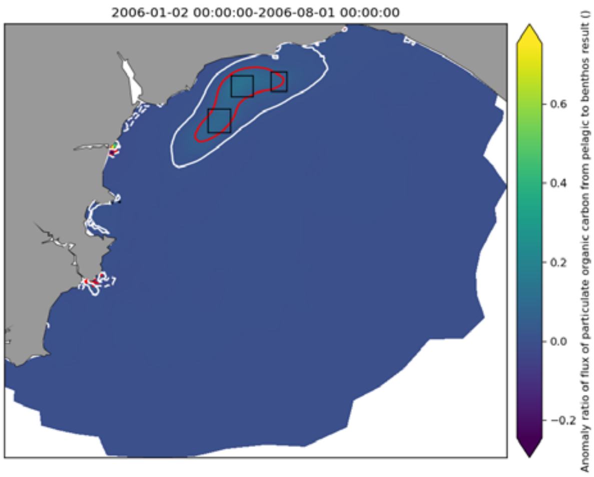
simulation and dashed for a decrease). All the metrics considered here show that the changes are limited to an area that include all 3 farms and extends no more than 60km^2 (e.g. Figure 21).

a)



b)

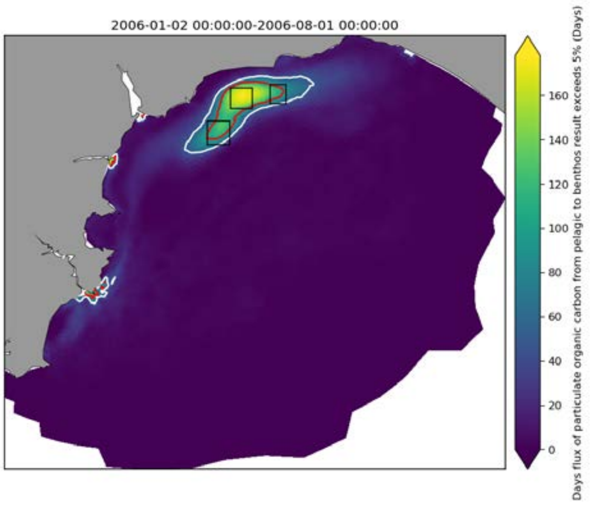


Figure 21. Spatial distribution of metrics of shellfish production impacts. Anomaly of the flux of Particulate Organic Carbon to the benthos. This includes contribution from pelagic plankton production as well as detritus originating from mussels. Shown is the farm scenario minus the baseline simulation. The red and white contours correspond to a 1% and 5% percent change respectively with respect to the baseline simulation or 50 and 100 days.

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The flux of POC into the sediment is one of the best captured effects because of it strong signal in the simulations. The largest part of the annual flux takes place during the last 3 months of the growing cycle associated with the fastest growth phase (Figure 19). The 5% changes with respect to the baseline simulations (red contour in Figure 21) reflect closely the spatial extent of the farms and the general direction of the tidal currents in the area. The largest impact is located within the central farm with 80% of the time showing an effect larger than 5%. The changes to the POC flux to the sediment have associated consequences to the benthic fauna (deposit and filter feeders) represented in the model. In respond to the increase in the flux, filter feeders decrease while deposit feeders increase in biomass possibly as a result of competition among the two functional types. The patterns are similar to those shown in Figure 21, with the 5% contour closely associated with the area of the farms.

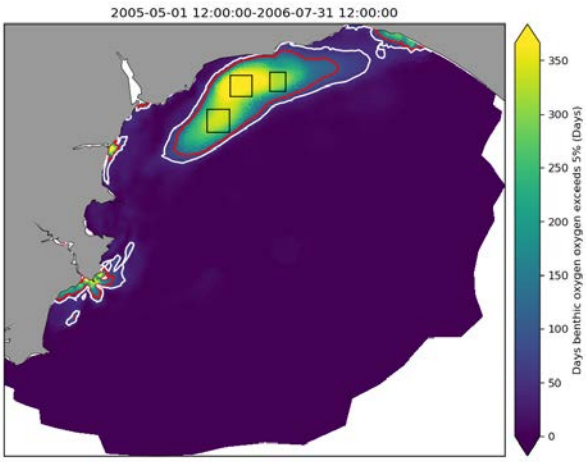

Figure 22 Days during which the sediment oxygen concentration exceeds a 5% change with respect to the baseline simulation.

The increase in POC deposition has a direct impact on the sediment oxygen concentration (Figure 22). Contrary to expectations, the sediment oxygen shows an increase with respect to the baseline simulation and an associated decrease in the oxygenated layer thickness (Figure 23)

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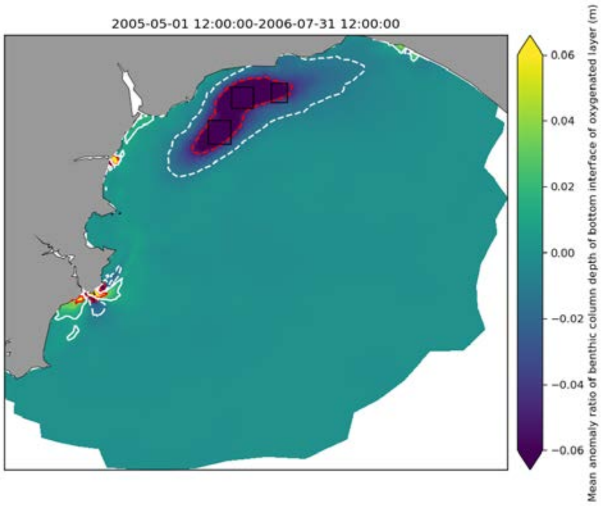
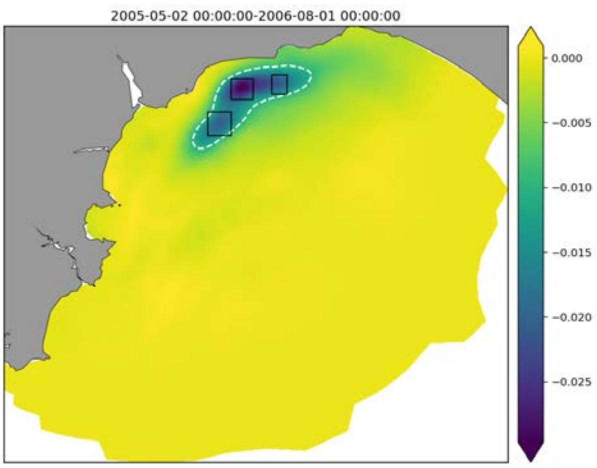


Figure 23 Mean anomaly ratio for the depth of the sediment oxygenated layer showing a shallowing of the redox horizon

A third aspect of the interaction is the assimilation of organic particulates by the mussels and the subsequent removal of a fraction of the pelagic planktonic ecosystem. This impact is on average smaller and much more localised than for the POC flux (Figure 24), never reaching 5% change and with changes exceeding 1% during ~15% of the time (Figure 24b) in one growing cycle.

a)



b)

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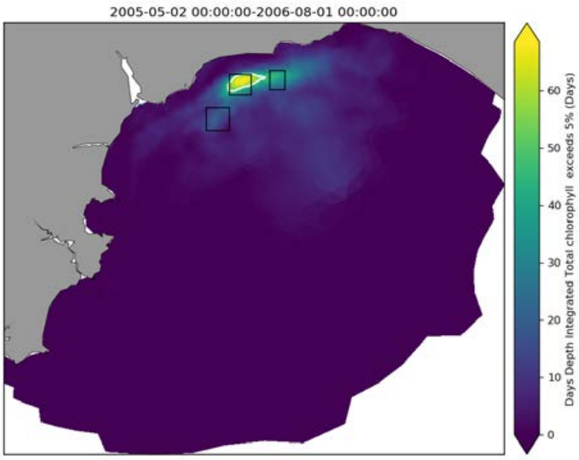

Figure 24 Impact of mussel production on total chlorophyll-a during the full first growing cycle.

The smaller impact on total chlorophyll-a is a direct consequence of the connectivity between the site and the rest of the shelf which ensures rapid flushing of the area as well as constant exchange of nutrients with deeper shelf waters.

The decrease in total chlorophyll-a is mirrored in all the other POC variables that mussels can assimilate with a knock on effect on light transmission. In this area, organic coloured particulates exert the largest control on light attenuation and their reduction results in a commensurate decrease in light absorption or increase in light transmittance.

3.4. Summary and evaluation of how this approach can be used to improve planning and management of shellfish aquaculture in Europe

The approach reported here is most suited to new farms during the licensing application period and the development of the business plan. While the resources to run our production and impact models is high and require expensive high performance platforms, the level of detail can provide a comprehensive evaluation of the potential impacts over a wide range of ecosystem characteristics. The approach can be customised to look at site specific characteristics (presence of deposition sensitive reef species such as pink sea fans (*Eunicella verrucos*a)) and can be further coupled to higher trophic level model systems such as Ecopath with Ecosim (EwE) to explore wider interactions with the regional ecosystem (i.e artisanal fisheries). The model can be run for longer periods (i.e. multiple growth cycles) to evaluate cumulative impacts (long-term community shifts driven by benthic-pelagic coupling or selective feeding on microzooplankton) as well as evaluating recovery pathways.

Commented [11]: [Please outline how this will be useful for aquaculture planning and licensing.
Is this useful for new farms or existing farms?

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The model system can be used to explore different production scenarios to feed into the company business plan as well as into the licensing procedure. These scenarios can include changes to the farm spatial configuration (i.e. orientation, rope density) to minimise long-term impacts and increase production, but also implement management approaches (i.e. staggered production) that could help maximise both production and economic profit (e.g. sustained production over longer periods to avoid market saturation and drop in prizes)

The spatial detail of our model approach can also contribute to optimise the design of the monitoring requirements by identifying areas most at risk of impact as well as indicating the frequency of observations required (weekly, monthly, event driven).

The lack of a site specific calibration for any of the model system parts means the model can be used in other areas. The model system is particularly well suited for estuarine and coastal locations, specially in regions that have good background data (e.g. bathymetry, digital elevation maps, river flows and associated nutrient concentrations, operational models) required to setup realistic model implementations.

- The model simulations can be adapted to different production scenarios to study how interannual variability can modulate farm-environment interactions and affect realised production. It could also contribute to the medium-term management of the farms, for example identifying areas better suited within the leased farm area or evaluating approaches to maximise mussel size vs overall farm production.

At the moment, there are very few examples of two-way coupling between shellfish production and biogeochemical models capable of evaluating the interactions across a comprehensive representation of marine lower trophic ecosystems (e.g. Ibarra et al., 2014). Because we are using a dynamic biogeochemical model we can evaluate how future possible changes caused by climate change impact on the volume and quality of the production. Different scenarios can be build around possible local area changes such as increase nutrient pollution from population growth or land use changes.

While the level of detail that this approach can generate is extremely high compared to other simpler options, the costs involved are high. Nonetheless, this approach is capable of evaluating multiple production sites at once, with the added benefit of enabling the description of potential interactions among farms. Because our model system stops at the lower trophic level, the definition of an appropriate carrying capacity methodology is still difficult to design. Ideally, the approach should be extended to higher trophic levels (i.e. local fisheries) to enable a more comprehensive evaluation of the interactions between the farm and local environment. In addition, longer simulations considering multiple growth cycles should be favoured to facilitate estimates of cumulative impacts and how the area might recover after the cessation of the aquaculture farms. Multiple growing cycles need to be considered so that year on year impacts can be fully captured.

Commented [RT12]: Can it be adapted for other areas or is it only suitable for certain scenarios

Commented [LF13R12]: I think it can be adapted providing that background data is there as you say. This would be useful for areas where a farm hasn't been established before.

Commented [RT14]: How this is an improvement on current approaches, what issue/gap does it address?

Commented [LF15R14]: Yes, as far as I know there are very few examples of this. The spatial and temporal resolution is a major step forward. Offshore sites in dynamic marine environments need this kind of approach rather than individual growth models based on a single point. Especially when the farm is as a large as this one.

Commented [RT16]: Mussel's response to contaminants such as organic pollution from waste, microplastics…
There is no feedback to hydrodynamics and in same regions this can be significant
Predation effort on mussels…

Commented [LF17R16]: Nice, I think this is covered well, also shows how the model is adaptable for other purposes and can be used to manage multiple-activities (e.g. fisheries), facilitating ecosystem-based management and contributing to marine spatial planning

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From the producer perspective, ShellSim could be extended to consider potential impacts of emergent (e.g. microplastics) and existing pollutants (organic nutrients) on mussel metabolism and hence growth.

To improve on the realism of the modelling system, the model should consider the feedback that exists between the mussels and ambient currents, with larger mussel slowing the flow of water through the farm. Such interaction is also present on other aquaculture activities such as bed oyster farms.

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4. Assessment of carrying capacity of a coastal bay in Ireland (Marine Institute, Ireland)

4.1. Background

Kilmakilloge harbour is a tidally dominated coastal area, located in the south-west Irish coast (Figure 4.1). This region is of high economic importance due to intensive marine farms and aquaculture activity therein. Thus, there is a constant need to manage existing farms or new potential “good site” for shellfish growth and production.

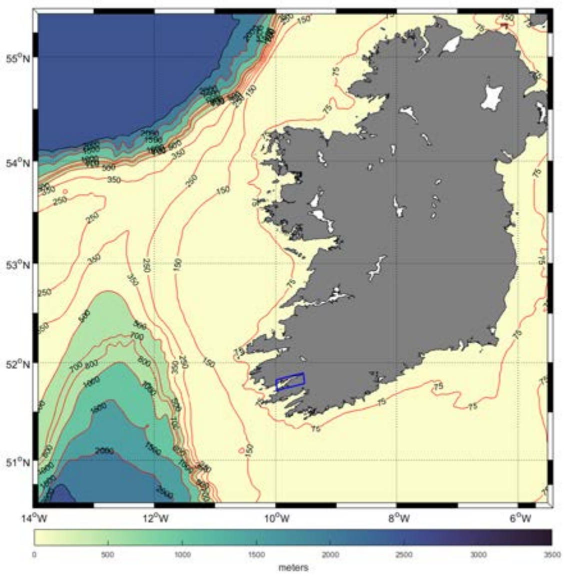

Figure 4.1. Geographic location of Kilmakilloge Harbour (blue box).

4.2. Description of the modelling approach

The modelling approach was performed in two phases. The first phase is a flushing study aiming to know the water renewal time scales in the bay. It was performed by coupling a circulation model with a particle tracking model:

1) Kilmakilloge model is a fully two-way nested 3D high resolution hydrodynamic model. It was developed at the Marine Institute (Ireland), using ROMS (the Regional Ocean Modelling System), an open-source, primitive equation, free-surface, hydrostatic, community ocean model (Shchepetkin and McWilliams, 2005). Simulations have been carried out for the time period between the 8th of February 2017 until the 26th of March 2017.

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2) Ichthyop v3.3 (Lett et al., 2008) is a free particle tracking Lagrangian model, developed to study the effect of physical (currents, temperature) and biological (growth, mortality) factors on ichthyoplankton dynamics. Ichthyop uses time series of velocity fields archived from Kilmakilloge model outputs.

In the second phase, a shellfish growth model, based on the dynamic energy budget theory (DEB; Kooijman, 2010) was intended to identify sites with good growth potential for shellfish farming in Kilmakilloge Harbour. This model, developed in Fortran by the Marine Institute, allows the user to define shellfish species through the specification of a set of parameters in an input file (Dabrowski et al., 2013). When this model is fully (i.e. dynamically) coupled to ROMS hydrodynamic and biogeochemical model enabling a 2-way communication, as presented by Dabrowski et al. (2013), it allows to simulate and study the interactions of shellfish with the marine environment (e.g. phytoplankton depletion, nutrient enrichment and the resulting impacts on biogeochemical cycling). Through the execution of this model for several different scenarios of varying shellfish stock in a given bay, the estimated or ecological carrying capacity can be derived. The aforementioned paper presents the implementation of the coupled ROMS-DEB models to rope mussels (*M. edulis*) in Bantry Bay, also located in the south-west of Ireland.

The available *in situ* data on chlorophyll_a in Kilmakilloge Harbour is too sparse and a complete 1 year of at least monthly time series of chlorophyll_a is currently unavailable for any location inside Kilmakilloge Harbour. Therefore, the DEB model has not yet been implemented. The existing satellite chlorophyll data is of too coarse resolution (300 m) to resolve chlorophyll distribution in Kilmakilloge Harbour. The MI modelling team is involved in an Interreg Atlantic Area project iFADO, where project partners are preparing high resolution satellite chlorophyll data for Kilmakilloge Harbour. Whilst samples for selected dates are available, the timeseries are not available yet. The MI modelling team plans to implement the DEB model in Kilmakilloge once this dataset becomes available.

4.3. Model output

A rectangular grid covering the Kenmare Bay with 120 meters resolution was developed and a second one with 40 meters resolution for Kilmakilloge hereafter named the donor and the receiver grid, respectively (Figure 4.2a). The model grid was built using high resolution bathymetric data, provided by the INFOMAR Programme (www.infomar.ie), Ireland's Integrated Mapping for the Sustainable Development of Ireland's Marine Resource.

The hydrographic observations presented in this work were collected by Ireland's Seafood Development Agency (BIM) in the framework of monitoring the Kilmakilloge Harbour, through the installation of three loggers located in stations A, B and C (Figure 4.2b). Data from these sites covers the period from February 15th 2017 to 4th of April 2017 and surpass the period of our initial hind cast for a few days. Loggers were set to record salinity and in situ temperature every one hour at 1 meter depth for all three stations, 4 meter at station A and 6.5 meters at station B. Unfortunately, no data was recovered from the bottom station (6.5 meters) due to logger fault.

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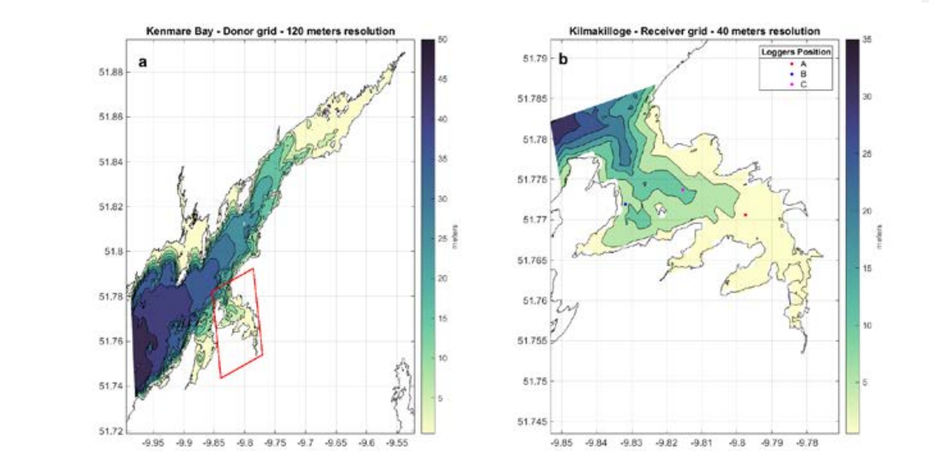

Figure 4.2. (a) Bathymetry (in meters) of Kenmare Bay and contact points of the receiver grid (red), (b) Kilmakilloge Harbour's bathymetry (in meters) and the position of loggers used for validation.

The hydrodynamic model validation is presented on Taylor diagrams (Figure 4.3): the correlation coefficient, standard deviation and centred root mean square differences for in situ water temperature at the three BIM stations - for 1, 4 and 6.5 meters. Figure 4.3 presents the comparison, in terms of statistics, between the observed and simulated values of in situ temperature at 1 m depth - left panel - and for 4 and 6.5 m depth - right panel - for all BIM stations inside Kilmakilloge Harbour. The model presents good skill and a correlation coefficient for temperature is close 0.8 for all stations and depths.

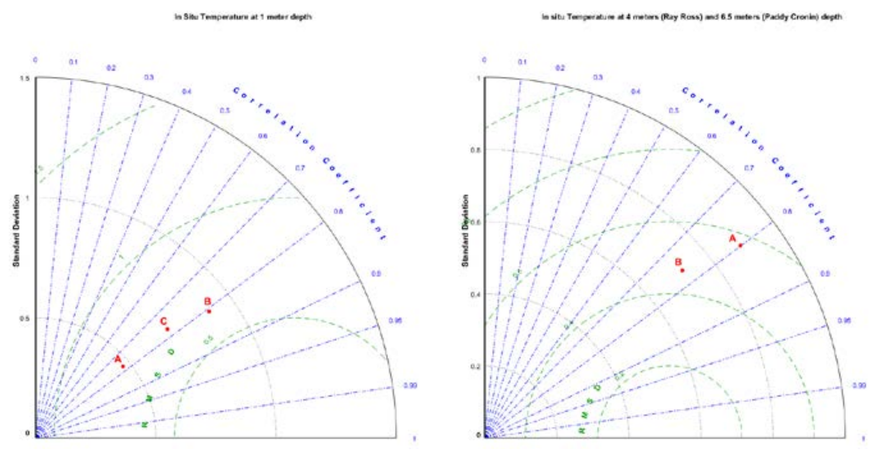

Figure 4.3. Statistical comparison between observed and simulated values of in situ temperature in all available depths for all stations in Kilmakilloge Harbour.

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Not having any tidal records for Kilmakilloge Harbour, we decided to use a coherence diagram to validate our model in terms of tides. Figure 4.4 (a) presents a coherence diagram and (b) the phase difference in degrees between observed and simulated data in order to investigate the ability of our model to reproduce the tidal signal correctly. From Figure 4.4, we conclude that the model is able to represent in an adequate way the dominant tidal harmonics, the semi-diurnal and the shallow water quarter diurnal, having high coherence scores for both (0.8) for 99% confidence level. The phase difference for the semi-diurnal constituent is close to zero and for the shallow water quarter diurnal almost 45 degrees.

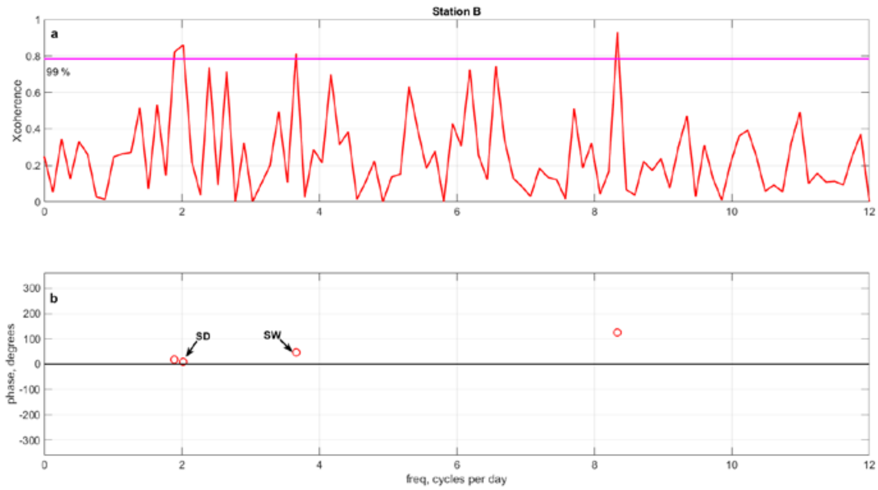

Figure 4.4(a) Coherence diagram and (b) phase difference in degrees for station B in Kilmakilloge Harbour. SD denotes semi-diurnal and SW shallow water quarter semi-diurnal constituents, respectively.

Overall, the model reproduces the dominant mechanism - tidal mixing - in an adequate way and there is a good match - especially for temperature - between the observed and simulated data.

Then, Kilmakilloge hydrodynamic model outputs are used by the Lagrangian particle tracking model. Passive particles were evenly distributed within the whole domain, which led to a total of 4287 particles for each run (Figure 4.5). Output positions were recorded every hour.

The average residence time is defined as *" the expected time during which 37 % of the material exists in the area under consideration"* (Dabrowski, 2005). In other words, the residence time of particles in the bay is the time required for which 1586 particles stay inside the bay.

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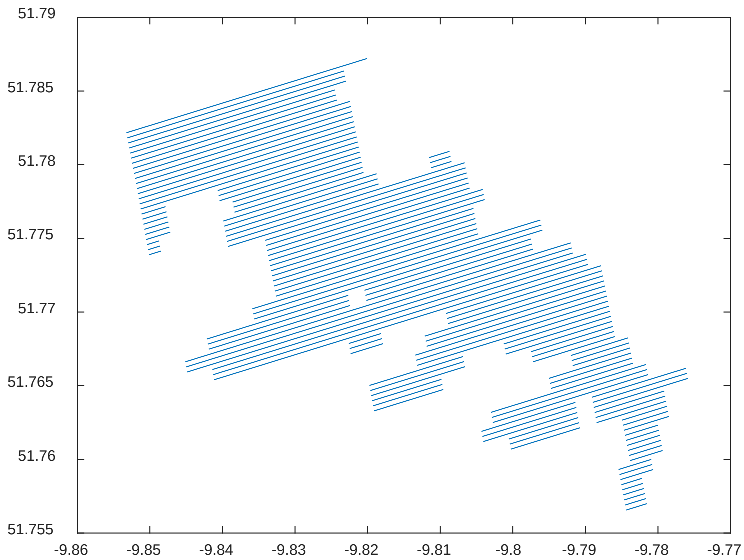

Figure 4.5: Initial positions of the passive particles placed inside Kilmakilloge harbour.

In order to get an overview of the dispersion of floating particles and estimate the residence time in Kilmakilloge harbour, two release conditions were tested: Neap tide and spring tide.

1). The Neap Tide: We calculated the residence time on the *20[th] February 2017 at 00h:00mn:00s (i.e after 13 days since release).* The number of particles function of time shows that during neap tide, the residence time in the bay is about 4.5 days (Figure 4.6). Residual currents, averaged over 25 hours of a neap tide are presented in Figure 4.7.

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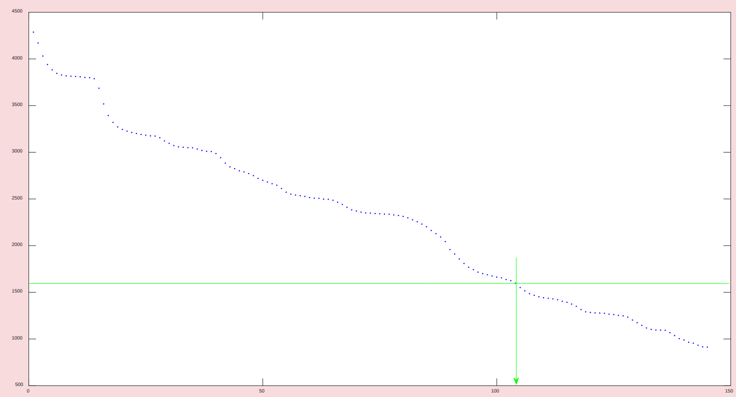

Figure 4.6. Number of particles function of time during a neap tide.

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I think it's clearer now

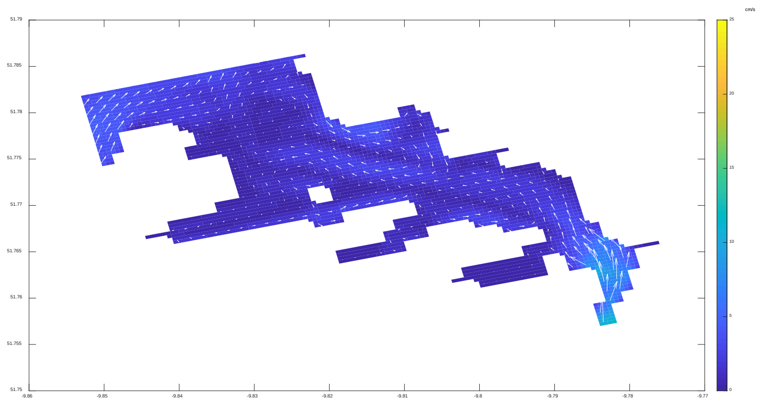

Figure 4.7. Residual Currents averaged over 25 hours of a neap tide.

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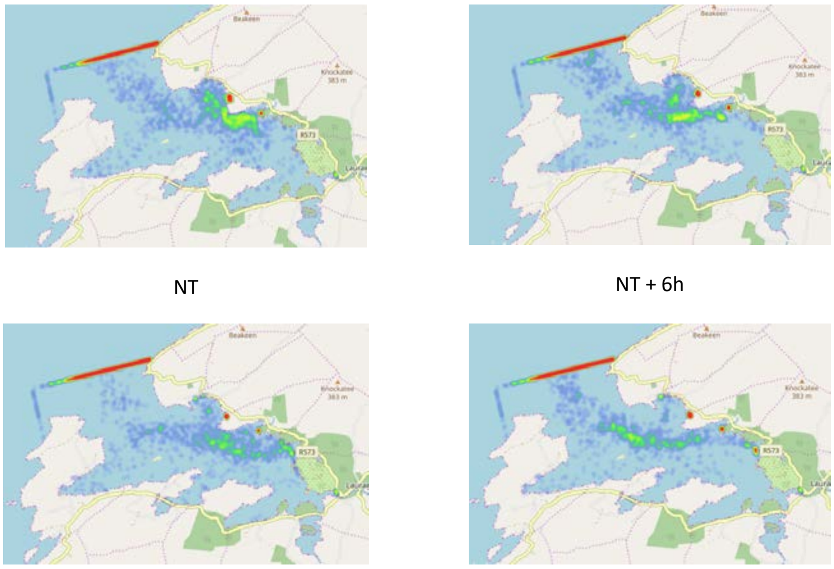

NT | NT + 6h

NT + 12h | NT + 18h

Figure 4.8. Spatial distribution of particles in Kilmakilloge Harbour every 6 hours, NT denotes the neap tide on the 20th February 2017 at 00h:00mn:00s (i.e after 13 days since release).

During neap tide, particles mostly tend to concentrate along the north-east part of the bay. This area is flushed slower than other parts of the bay. There are less particles in the inner sections of Kilmakilloge. Overall, it can be concluded, that the southern shores of Kilmakilloge Harbour are flushed faster compared to the northern shores.

<u>2). The Spring Tide</u>: We calculated the residence time on the *28th February 2017 at 00h:00mn:00s (i.e after 21 days since release).* The evolution of the number of released particles function of time is presented in Figure 4.9. It shows that during spring tide, the computed residence time is about 4 days. Figure 4.10 shows the residual currents in spring tide, averaged over 25 hours of a spring tide.

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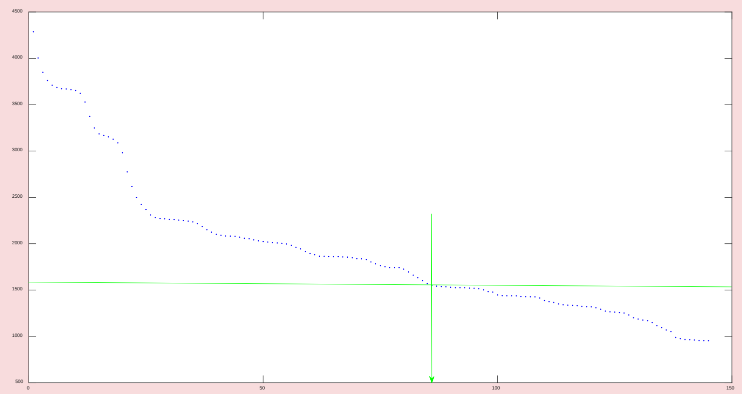

Figure 4.9. Number of particles function of time during a spring tide.

Commented [AO19]: Figure changed here as well

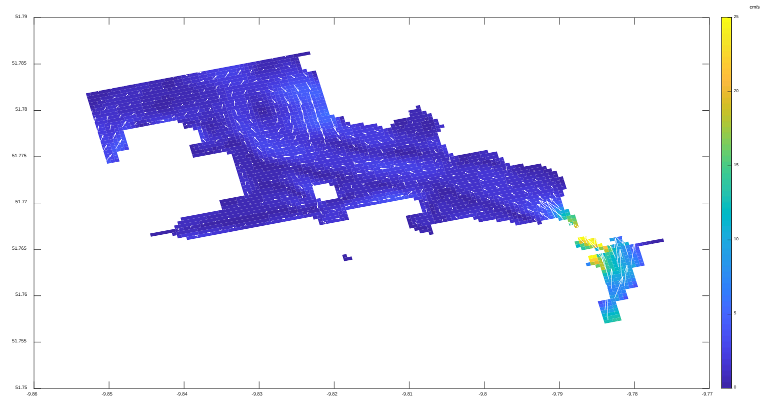

Figure 4.10. Residual Currents averaged over 25 hours of a spring tide.

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ST

ST + 6h

ST + 12h

ST + 18h

Figure 4.11: Spatial distribution of particles in Kilmakilloge Harbour every 6 hours, ST denotes the spring tide on the 28th February 2017 at 00h:00mn:00s (i.e after 21 days since release).

During spring tide, particles are visibly more concentrated in the inner sections of the bay, compared to the outer. Similar to the neap tide, they can be found in greatest numbers along the northern shores, but visibly further upstream. The outer parts of the bay appear to be relatively uniformly flushed, as manifested in the near-uniform distribution of particles. Such distribution may be attributed to the gyre that develops in the outer section on a spring tide (see Figure 4.10).

Results from the flushing study have shown that residence time for Kilmakilloge harbour is relatively "short", ranging from 4 to 4.5 days. This can be attributed to the geometry of the bay, its shallow water (maximum depth of about 40 metres) and the importance of tidal range in there. In fact, tidal oscillatory movements of water inlet and outlet are sufficient to in remove the particles after four days.

These results are important for management applications, particularly, for shellfish farming. License applications for shellfish farming have previously been rejected in Ireland on the grounds of poor flushing.

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4.4. Summary and evaluation of how this approach can be used to improve planning and management of shellfish aquaculture in Europe

[Please outline how this will be useful for aquaculture planning and licensing.

- Is this useful for new farms or existing farms?
- Can it be adapted for other areas or is it only suitable for certain scenarios
- How this is an improvement on current approaches, what issue/gap does it address?
- Any limitations/areas that need further work
- Anything else you think is useful

Commented [TD20]: Lynne, we did not provide any text here yet. Are you happy for us to discuss it here on the basis of our previous work for Bantry Bay, since we were unable to implement the DEB model in Kilmakilloge due to the lack of data.

Commented [LF21R20]: Yes, please complete this section based on Bantry Bay. Thanks!

I think it is a good point about the data, and it shows that these modelling approaches are not always straightforward to apply. This is important for people to understand if they want to use this approach.

ROMS-DEB model, developed by Dabrowski et al. (2013) was previously applied by the Marine Institute to Bantry Bay, which is located in the SW of Ireland, similarly to Kilmakilloge Harbour. The capability of the model to reproduce the growth of rope mussels and their interaction with the environment was studied and documented in Dabrowski et al. (2013). This model was also subsequently parameterized also for Crassostrea gigas and implemented in the Tagus estuary, Portugal. The DEB model can be relatively easily parameterized for different species of shellfish, however, the underlying numerical model of a given area needs a significant effort to be developed. Both ROMS and DEB models are generic, though, and with appropriate investment of resources can be adapted to any other region.

The modelling approach consisting of a coupled ROMS-DEB model ~~presented in this work~~ allows for the assessment of the impacts of aquaculture activities on water quality, quantification of the production and ecological carrying capacities and improvement of our understanding of the ecosystem functioning with particular emphasis on interactions between various trophic levels. This modelling system is particularly useful to manage existing or new "potential" farms with favourable conditions for shellfish production. It is a powerful tool enabling to run numerous "what if" scenarios, e.g. change in standing stocks, removeal of existing and addition of new farms, relocation of existing farms, etc.

This study adds to the growing evidence that models based on the DEB theory are capable of reproducing growth of various shellfish species in different environmental conditions. In fact, it can be adopted for several different scenarios for other species and other sites of interest to shellfish aqualculture, where reliable input datasets (standing stock, shell lengths, hydrological and biogeochemical fields, chlorophyll_a and temperature) are available for model forcing.

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~~The model was applied to rope mussel (Mytilus edulis) cultures in Bantry Bay, Ireland (Dabrowski et al., 2013) and parameterized also for Crassostrea gigas for the implementation in the Tagus estuary, Portugal.~~

This study shows that the impacts on ecosystem dynamics can be assessed using the presented modelling system making it a powerful tool to support sustainable management of shellfish aquaculture.

The presented model of the interactions between mussels and the ecosystem is consistent with the DEB model formulations and predicted changes in shellfish bio-energetics. It conserves mass by accounting for the allocation of relevant amounts of C and N in an organism, which brings this modelling attempt a step further from these recently reported. It is mass conserving and both ROMS and DEB are fully dynamically coupled, enabling modelling the depletion of food (phytoplankton, detritus) and nutrient enrichment through excretion of ammonia and egestion of faeces. It is also recommended that for better representation of bio deposition by bivalve cultures and its effects on nutrient cycling these models are further expanded to describe benthic processes and their interactions with the pelagic environment.

Another limitation is associated with access to High Performance Computing environment (highly complex and computationally very expensive) and adequately skilled staff to set it up and run.~~However, the model is highly complex and requires expensive hardware (High Performance Computing) to run~~. Currently, it serves as a research model.

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5. Recommendations for improved carrying capacity and production models for shellfish aquaculture in Europe

Commented [LF22]: All: Please have a read through and make sure this is ok. Make any changes or add anything else you think should be included

The main recommendation from this work is that modelling approaches that consider the spatial and temporal variation in an area should be used rather than discrete points. Each case study has highlighted how the environmental conditions vary spatially and temporally and the implications this has for shellfish culture. For planning and licensing, focusing on individual locations within a coastal area may be appropriate in the case of existing farms or small systems, but, increasingly there is a need to focus on the wider area and evaluate conditions across a coastal bay or further offshore.

Shellfish growth and production models can use measured data from discrete points, however for most areas, the data resolution is likely to be insufficient and will not cover the spatial area or time series required to capture the conditions. As shown here, EO data can provide the necessary information at a scale that can be useful for producers and regulators, allowing identification of the most suitable sites (Section 2). Although the models require time, data and expertise to develop and implement, this is a more cost-efficient method compared to an extensive fieldwork campaign. There can be challenges obtaining data (as described in Section 4) which can delay the implementation of a model so decision makers must consider time required to obtain the necessary data when outlining a timeline for development and use of these models. As with any modelling approach, the quality of the output data depends on the input data.

Another recommendation is that models should be used to simulate alternative scenarios as part of the planning process to ensure the sites and production strategies are suitable. The case study in France (Section 2) demonstrates the usefulness of modelling different sites and varying production strategies. The models can be used to identify locations for specific stages of shellfish production and producers can evaluate the trade-offs between leasing one site over another. The visualisation of model outputs in maps can also support the licensing process as it facilitates stakeholder interaction and public engagement. Furthermore, the outputs can also be used with other site suitability criteria and constraints to select sites in an objective manner (Barillé et al., 2018) and can be used in marine spatial planning of all activities in an area.

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Regulators and administrative authorities can also streamline the licensing process using hydrodynamic models. In Ireland many shellfish applications have been rejected due to poor flushing, but hydrodynamic models (such as the one demonstrated in Section 4) can be used to simulate flushing and water exchange, thus determining if a bay is suitable or not for production. The relevant authority can then identify areas or zones that are potentially suitable for new, additional or expanded shellfish farms. There are other considerations for the planning application, such as production potential and feasibility, but since poor flushing is a main reason for rejecting licences it is more efficient if the models provide this information upfront so producers have background knowledge prior to applying. Furthermore, regulators and authorities could take this further and use together with shellfish production models to determine overall carrying capacity which may help establish leases that applicants can apply or bid for depending on the licensing set-up for that country.

Hydrodynamic models coupled to biogeochemical models can simulate the environmental conditions at shellfish farms. These models are capable of high spatial resolution at fine time-steps which mean they are capable of very detailed simulations. However, development and implementation can be time consuming and expensive, usually involving supercomputer time and highly trained experts. Use of this type of modelling approach is likely to be most appropriate for sites where there are particular concerns, for example risk of cumulative impacts, Marine Protected Areas (MPA), impact from other activities or the scale of the system could result in wider ecosystem impact. The latter has been demonstrated in the case study in Lyme Bay in the English Channel, where FVCOM-ERSEM coupled to ShellSim was used to assess production potential, carrying capacity and ecological impact for a large-scale offshore site (Section 3). Such information would be difficult to obtain without models, especially given the large scale of the system and dynamic nature of the environment and in the absence of sufficient information, decision makers may be likely to reject an application. Thus, for complex developments such as the mussel farm in Lyme Bay, it is recommended that these computationally-intensive models are used rather than more simple empirical approaches. Furthermore, with further investment, it would able be possible to add other components which consider other species and activities to the modelling approach to support ecosystem-based management, marine spatial planning and integrated-coastal zone management. This may be something that local or national governments would implement at areas that are important for biodiversity, culturally and/or the economy.

Coastal areas traditionally used for shellfish culture are under increased demand from other activities so producers and regulators must identify the most suitable locations for culture which involves evaluating if there are sufficient natural resources (e.g. food, spat) for the shellfish and also assessing potential environmental impact. This is particularly important as the industry seeks to establish sites in new areas which have not been used for farming before, as well as areas where there are already existing farms. The modelling approaches here represent improved methods that can overcome some of the bottlenecks in the licensing process where there is insufficient information to make a decision on whether or not the site is suitable for shellfish production.

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An Bord Achomharc Um Cheadúnais Dobharshaothraithe
Aquaculture Licences Appeals Board

CEO Marine Institute
Rinville
Oranmore
Co Galway

16 April 2021

Our Refs: AP12/2019. AP13/2019, AP14/2019, AP15/2019, AP16/2019, AP17/2019 and AP18/2019
Site Refs: T06/364A, T06/35A, T06/106, T06/254A, T06/495A, T06/513A and T06/360A

Re: Appeals against the decisions of the Minister for Agriculture, Food and the Marine to refuse to grant Aquaculture and Foreshore Licences for the cultivation of mussels using longlines on the foreshore on the above Site references, Kilmakilloge harbour, Co. Kerry.

Dear CEO,

We refer to Appeal received by Aquaculture Licences Appeals Board (**ALAB)** against the decision of the Minister for Agriculture, Food and the Marine (**the Minister**) being ALAB Appeal Reference AP12/2019, AP13/2019, AP14/2019. AP15/2019, AP16/2019, AP17/2019 and AP18/2019, accessible via the following link: http://alab.ie/boarddeterminations/2019/

Pursuant to **Section 47(1)(a)** of the Fisheries (Amendment) Act, 1997, as amended, ("the Act"), where the Board is of the opinion that any document, particulars or other information is or are necessary for the purposes of enabling the Board determine the Appeal, it may serve a notice on a party requiring that party to submit to the Board such documents, particulars or other information as are specified in the Notice.

Having considered the appeal and the information provided to it, the Board has determined that further documents are necessary for the purposes of enabling the Board determine the Appeal.

The Board hereby requires Marine Institute to provide the Board with:

1) Details of any known Inshore fishing activities in Kilmakilloge Harbour for the past 20 years;

2) Details on water flow or flushing rate within Kilmakilloge Harbour, or any reports or modelling done on same by or on behalf of, or available to Marine Institute.

3) Any other information which Marine Institute believe is relevant to the licencing and good management of aquaculture at Kilmakilloge Harbour of an economic, environmental, ecological or societal nature.

In accordance with section 47 (1) (a) of the Act, the Board requires this information within **30 days** of receipt of this letter. Please note that if the documents, particulars or other information specified above are not received before the expiration of the period specified above, or such later period as may be agreed by the Board, the Board will, without further reference to you, determine the appeal.

Please also note that a person who refuses or fails to comply with a requirement under section 47 (1)(a) shall be guilty of an offence.

Yours sincerely

Mary O'Hara

____

Mary O'Hara
Secretary to the Board

c.c Joe Silke

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