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Environmental Impact Statement (EIS)
for a proposed salmon farm site at
Shot Head, Bantry Bay,
County Cork, Ireland.

Volume 1 of 3.
Main EIS document.
Contents to Volumes 1 and 2.

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Section 1.

Introduction.

1.1. Background to the proposed project.

Bantry Bay is the largest of the *rias*, or drowned river valleys, in the southwest of Ireland. From its eastern end at Ballycrovane to its entrance to the Atlantic, between Sheep's Head and Dursey Island, it is 39km long, possesses some 200km of coastline and has a nominal sea area of some 230km^2.

There has been salmon farming in Bantry Bay since the 1970's, when local fishery interests established Roancarrig Salmon Farm, between Roancarrig Rocks and Bear Island. The Roancarrig operation was acquired by Salmara Fisheries, a wholly-owned subsidiary of the Electricity Supply Board (ESB) in or about 1986 and was operated by them until 1994. Salmara also established a smolt site[1] in Bantry Bay, under trial licence, at Doonbeg Head, on the southwest corner of Bear Island, in 1992. These sites were purchased by Gaelic Seafoods Limited in the disposal of Salmara by the ESB, along with two licensed marine salmon farm sites and one smolt site (the latter under temporary licence) in Kenmare Bay and freshwater salmon hatcheries elsewhere in the country.

Gaelic Seafoods sold these operations to the Murpet Fish Company in 1999, subsequently renamed Dafjord Ireland Limited, who operated the sites as Beara Atlantic Salmon Ltd. Dafjord commissioned an Environmental Impact Statement (EIS) in 2000, for the enlargement of the Roancarrig site and full licensing of the Doonbeg smolt site, as well as the enlargement of the two grow out sites and full licensing of the smolt site in Kenmare Bay, with a planned total annual salmon production between the sites of 6,000 tonnes. In the event, the only part of this EIS which went to licence application was the Roancarrig site, and the establishment of a separate smolt site at Roancarrig. These sites were licensed for a combined annual production of 2,000 tonnes of salmon in 2003. However Darfjord Ireland and Beara Atlantic Salmon went into receivership in 2004.

1 A smolt site is used for the cultivation of young salmon (smolt), from point of transfer from freshwater to seawater to an intermediate weight, for up to one year at which point they would be transferred to a grower site.

John Power, fisherman and former Chairman of the Castletownbere Fisherman's Cooperative, established the first of two sites for the farming of sea-raised rainbow trout in Berehaven, in about 2000. In due course, Mr Power and parties purchased the assets of Beara Atlantic Salmon and some other Dafjord interests in salmon farming in Ireland from receivership and established Silver King Seafoods Limited, based in Castletownbere.

The late nineties also saw the licensing of two salmon farm sites by Laschinger Holdings Limited, in the vicinity of Whiddy Island, at the eastern end of Bantry Bay. Laschinger also became involved in salmon farming operations in Kenmare Bay. However Laschinger disposed of its interests in salmon farming in Ireland in about 2008 and their former Bantry Bay sites are now operated by Fastnet Irish Seafood Limited, based near Bantry.

Silver King Seafoods' assets in Bantry Bay and Kenmare Bay were acquired by Marine Harvest Ireland between late 2008 and early 2009. Mr Power retains a role in the revised company, as Manager of the sites in the southwest of Ireland, which now trade as Marine Harvest Ireland. Marine Harvest Ireland is the largest aquaculture company in Ireland, currently employing over 250 people between its salmon farms and hatcheries in Donegal, Mayo and now in the southwest. Internationally, Marine Harvest is a global force in aquaculture, with farming operations in Scotland, Norway, Canada, Chile and elsewhere.

1.2. A note on awards and standards.

MHI have pioneered the achievement of many awards and standards in the aquaculture industry, under which they operate their hatcheries, marine farms and processing operations. They were the first aquaculture company to achieve the Irish Quality Association (IQA) Q-Mark and have since achieved the Fish Processing Category of the IQA National Hygiene Awards. The company has also retained the Excellence Ireland Hygiene Certificate for many years and won the Excellence Ireland Triple Hygiene Award in 2003. As well as the Q-Mark, MHI have achieved the Irish Quality Salmon Standard for all company operations since 2000. The company operates under the ISO 9001 International Quality Management Standard and was the first fish farming company in the world to achieve the ISO 9002 International Quality Systems Quality Assurance Standard.

MHI have been Northwest Regional winners in the NISO National Safety Awards and NISO Occupational Safety Awards. They were also the first

company in Ireland to achieve the OHSAS 18001 Certification of Safety Management Systems and the Excellence through People Training Award.
MHI was also the first aquaculture company to achieve the BIM Ecopact Award and received a judges' commendation in the Managing for Sustainable Development Award category of the IBEC Environmental Awards in 2003 / 2004. MHI was the first Irish primary food producer to be certified under the ISO 14001: 1996, the International Environmental Standard.

MHI's packing and processing operations are certified under the internationally recognised British Retail Consortium's (BRC) Standard for Food Safety.

In the particular context of MHI's southwest operations, these have followed in the footsteps of the company's Clare Island operations, which produce only organic salmon, using only organically reared salmon smolt, produced in the company's hatcheries. To this end, MHI is certified under three separate internationally recognised Organic Standards; Naturland, Bio Suisse and Global G.A.P. in full compliance with EU Directive EC/710/2009[2]. Organic standards are appended in Appendix 5. If licensed, the proposed Shot Head site will be operated and managed with the benefit of these standards as a fully organic unit, using low stocking density, organic smolt and organic feed.

1.3. Rationale behind the requirement for a second MHI site in Bantry Bay.

Marine Harvest Ireland is in the process of rationalising and upgrading its operations nationally, with the main objective of implementing current best practice in its three main production areas, in Donegal, Mayo and the Southwest. This will comprise the standardisation of equipment and operational practices between regions and the development of a nationwide stocking, harvesting, fallowing and rotation program in compliance with the principles of Single Bay Management[3].

The marine salmon farm production cycle lasts a nominal two years, comprising the transfer of *smolt* (young salmon ready to move from freshwater to seawater) to sea cages, their growth to harvest and the fallowing of the production site until the commencement of the next production cycle, at the same time in Year 3.

2 MHI Organic Salmon products from Clare Island are also identified by a Protected Geographical Indication (PGI), an EU quality indication.

3 Single Bay Management, which was integrated in due course into Coordinated Local Area Management Schemes CLAMS) in a number of Irish bays and loughs (excluding Bantry) was first introduced by the then Department of the Marine in the early 1990's.

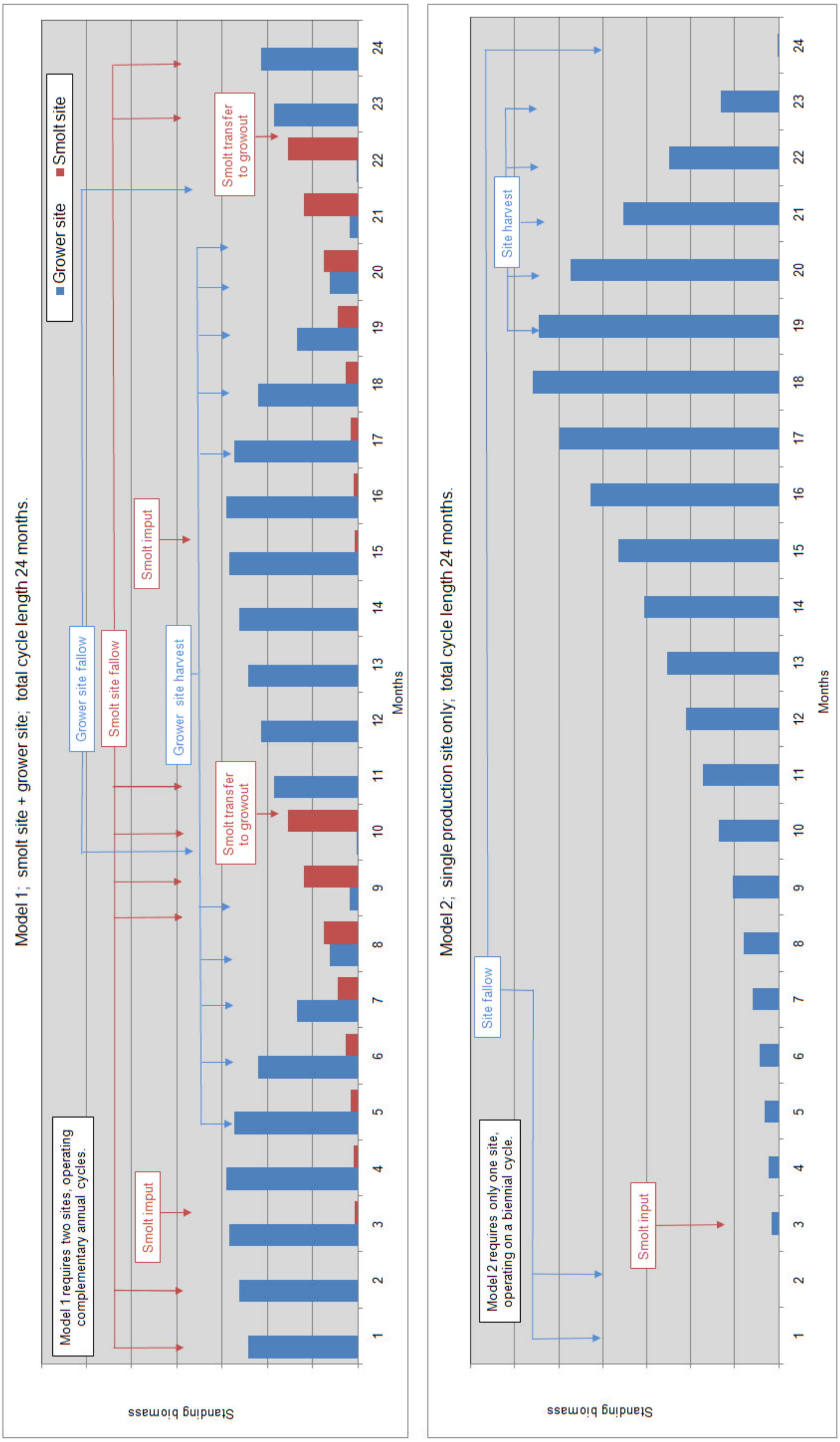
Farmed salmon are now fitter and grow and survive better than a decade ago. This is due to the steep learning curve undergone by the industry, mainly in terms of genetic improvement, better stock control, lower stocking densities and improved nutrition and feed management. There has also been a fundamental improvement in stock transfer practices during the production cycle. The former production model (see Figure 1, Model 1) comprised the transfer of smolt to a *smolt site* annually, where the young fish were grown from, say 75g to an intermediate weight of, say, 1kg. Fish were then transferred to a *grower site*, to be ongrown over their second sea-year to a mean harvest weight of, say, 3.5kg to 4.5kg. When not in use, each site was left fallow until the next cycle to break possible disease and parasite life cycles. Thus both the smolt site and the grower site were operated on annual cycles, giving a total production cycle time of 24 months to harvest, including fallowing. However this mode of operation has a some disadvantages, including the need to move the stock mid-cycle, which temporarily slows growth and can have other implications for stock health. It can also limit fallowing time, in particular at the grower site, before it must be restocked.

Innovations in salmon farming techniques have led to a new production strategy, where the same site is occupied from smolt to harvest without an intermediate transfer (see Figure 1, Model 2). However the base production cycle from smolt to harvest, including fallowing, remains two years in length, although mean harvest weight is now generally larger (4.5 to 5.6kg) and the fallowing time longer. Growth from smolt to harvest now takes 20 to 22 months, leaving 2 to 4 months during which the site can be fallowed at the end of each two-year production cycle. Once fallowed, the site can be restocked for its next production cycle. However, in operating Model 2, harvesting only occurs over a number of months towards the end of the second year of the cycle. Thus, in order to enable annual harvesting from a production area, this strategy requires the rotation of two similar sites in the bay (or two groups of sites in separate bays), such that each is stocked in alternate years, working on the basis of a 24-month production cycle on all sites.

To take best advantage of these innovations, MHI now wishes to license a second site in Bantry Bay, with which it will be able to operate the improved stocking strategy; see also Section 3.2. A suitable site has been identified near Shot Head, 8km east of the MHI Roancarrig site. The site has been selected after an analysis of a number options in the bay. The location of the proposed Shot Head site is shown in Figures 2 and 3.

The purpose of this EIS is to report on the Environmental Impact Assessment of the Shot Head site, as part of intended Aquaculture and Foreshore Licence applications for the site, as required by the Fisheries (Amendments) Act 1977.

Figure 1.
EIS for a salmon farm site at Shot Head.
Comparison of production strategies; Model 1 vs. Model 2.



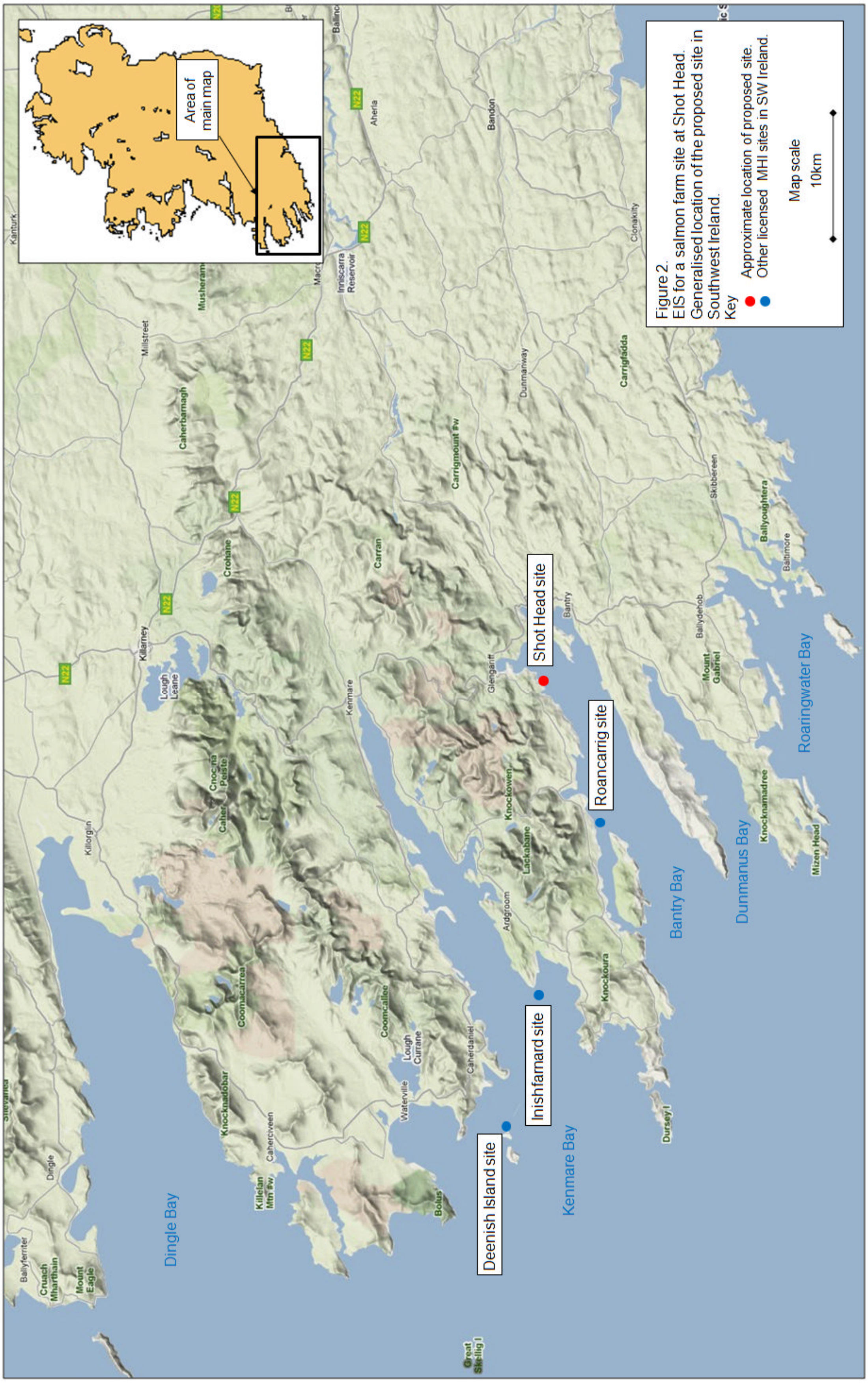


Figure 2.
EIS for a salmon farm site at Shot Head.
Generalised location of the proposed site in Southwest Ireland.
Key
● Approximate location of proposed site.
● Other licensed MHI sites in SW Ireland.

1.4. Site choice

The siting of any marine finfish farming installation is subject to a number of important constraints and considerations, namely:-

- Requirements of other users of local waters and infrastructure, in particular fishermen and tourism and leisure interests.
- Geography, hydrography and bathymetry of the locality.
- Hydrodynamic and meteorological influences on local waters.
- Natural history of the local lands and waters.
- Requirements of national law and EU directives.
- Proposed, pending and existing licences of other aquaculture users.
- Regional and local infrastructure (adequacy of piers, roads etc.).
- Other social, cultural and aesthetic considerations in the area, in particular Visual Impact.
- Logistical and geographic considerations in respect of the operation of sites and relative proximity to suitable processing and packing facilities.

Bearing in mind these limitations to site selection, the number of locations suitable for salmon farming activities in any locale is limited from the outset and Bantry Bay is no exception. A primary consideration is relative exposure to marine and meteorological forces. This is a particular issue in the case of the loughs and bays along Ireland's west coast, which face into the prevailing wind direction (west to southwest), from which the most frequent and the strongest winds blow and from which the strongest Atlantic storms approach. Marine cage farm design has progressed considerably during the last fifteen years or so with advances both in cage specifications and structure and in mooring technology. This has enabled structures to be moored and operated in more exposed conditions. It has also offered greater security against weather-related events such as fish escapes. However site selection can be limited by operational access and safety considerations, if a candidate site area is too exposed, to prevailing conditions in particular.

Bantry Bay faces roughly WSW into the Atlantic (292º). The most severe storm and wind conditions, with the greatest frequency, approach the bay from an aspect of approximately 60º, between 270º (west) and 210º (SW / SSW), with peak storms approaching from 240º. (See Wave Climate, Section 2.4).

Under these conditions of exposure, the first preferred option for a large salmon farm site is occupied by the existing MHI Roancarrig site, because this is afforded shelter from the WSW by the topography of Bear Island, one of the largest of Ireland's offshore islands. There is no other candidate site area so far west in the bay because there is no other shelter from prevailing conditions

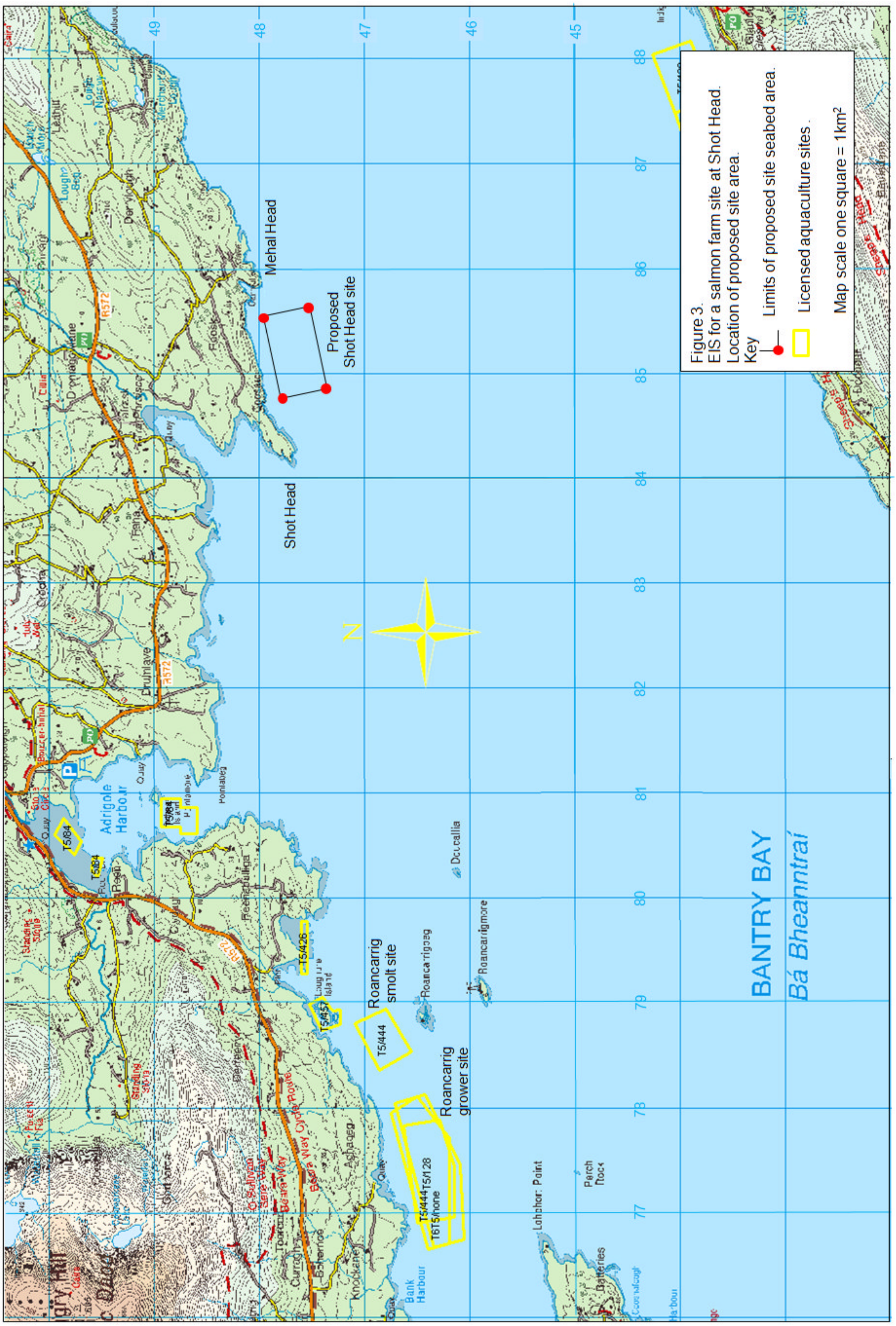


Figure 3.
EIS for a salmon farm site at Shot Head.
Location of proposed site area.

available. Going eastwards up the bay, the Shot Head area offers the second preferred option because it has adequate depth, is still afforded some shelter by Bear Island, has no other major bay stakeholder dependant on it and is not populated by an exploitable, sustainable fishery resource (see Section 6.2)

On the southern shore in the same area of the bay, with some shelter afforded by the Sheep's Head peninsula, the wave climate is similar to that at Shot Head. However, the area lacks a sufficiently large vacant site option with adequate depth. For the most part, it lies within a Designated Shellfish Area and is already occupied by a considerable number of licensed shellfish sites; see Figure 7.

Going further east, whilst the bay offers progressively increasing shelter, due to its shoreline topography and increasing distance from the Atlantic, areas with adequate depth become fewer. In addition, the needs of maritime traffic and existing users, including the Tarmac Fleming Quarry at Leahill, the Conoco Philips Bantry Bay Oil Terminal on Whiddy Island, the fishery harbours at Bantry and Glengarriff and traditional inshore fishery operations, as well as mussel lines and a second salmon farm operator leave no sufficiently large, vacant site options available.

In summary, in researching options for a suitable site for a second Marine Harvest salmon farm site in Bantry Bay, it is submitted that :-

- The Shot Head site been selected with full consideration of the needs of all other users of local waters and infrastructure.

- The proposed site and operation will impart only negligible, transient impacts on the seabed and waters of Bantry Bay and on its habitats and stakeholders.

- The operation of the Shot Head site will provide benefits to the area and further afield by way of increasing steady, secure full-time employment and by the sustainable exploitation of Ireland's valuable marine resource, thereby also supporting downstream industry and export earnings.

- The Shot Head site is the best and probably only option still available in Bantry Bay, which satisfies the rigorous selection parameters set down by the regulatory authorities, MHI and others, for the siting and operation of marine salmon farms.

1.5. Shore-based facilities; overview.

Marine Harvest's shore-based facilities in Bantry Bay comprise an office on The Pier, Castletownbere and the company Operations Yard on Dinish Island within the Castletownbere Harbour Centre (see Figure 5). The operations yard is used for storage, diver services and net cleaning, disinfecting and mending, as required. Vessels use the pier facilities, both within Castletownbere Port and at the Pontoon public pier at Beal Lough, east of Castletownbere.

Harvests are unloaded live from well boat to road transport in Castletownbere Port for delivery to Marine Harvest's packing facilities in Rinmore, County Donegal. Feed supplies are normally delivered by truck to Castletownbere for transfer to company vessels for delivery to site. Small feed deliveries will be transferred to vessels at other Bantry Bay public piers, where access and space are adequate for the intended purpose, including the Pontoon pier.

1.6. Floating facilities; overview.

See also Section 3.3. For each licensed site, the company's static floating facilities comprise the cages and related service equipment, moored at sea. Once the siting criteria, discussed in Section 1.2, have been satisfied, the numbers and types of cages and ancillary equipment used are governed by:-

- Site conditions, in particular site depth.
- Space requirements of the stock during the production cycle.
- Production cycle duration.
- Salmon market price relative to mean fish weight.
- Requirements of organic standards of salmon culture, which apply to Marine Harvest's Bantry Bay sites.

The proposed seabed area for the Shot Head site (the area for which the licence is granted in the case of Aquaculture Licence applications) is 850m x 500m, or 42.5 hectares. An Aquaculture Licence and Foreshore Licence require that all cage structures, moorings, anchors and ancillary equipment for the operation must lie within the licensed area. This area is sought in order that there is adequate flexibility available to the company for the operation of the site within the licensed area. In particular, the seabed area proposed allows sufficient room for the cages to be moored over completely new ground, should this be required, in the course of time, without any of the moorings falling outside the licensed area. The relative proportions of the proposed sea bed area and cage array are shown in Figure 4, which includes the coordinates for the limits of the seabed area.

The only visible static structures on the site will be the cage rings (with top nets, required to prevent bird predation and damage to fish), grid buoys, anchor buoys, navigation lights and the feed barge. The cage rings have a circumference / diameter of 128m / 41m giving an individual cage surface area of 1,300m^2. The number of cages deployed for the bulk of the 24-month production cycle will be twelve, with a combined surface area of 15,650m^2, or just over 1.5 hectares, within the site area of 42.5 hectares.

The floating cage rings will be held in position, in a 6 x 2 cage formation, by a submerged (that is not visible at the surface) mooring grid. Each cage will be moored within a 70m x 70m grid square. The total area of the submerged grid, comprising 6 x 2 grid squares, will measure 420m x 140m, or 58,800m^2, or approximately 6 hectares. Thus the cage rings will occupy less than 4% of the proposed seabed area for licence application, whilst the mooring grid will occupy some 14% of the proposed seabed area for licence application.

The mooring grid will be attached to the seabed by some 26 mooring anchors, each taking up a seabed area of approximately 2m^2 (4’6” x 4’6”). These will lie around the perimeter of a seabed rectangle much larger than the visible cage area above it. Assuming a maximum horizontal length of axial moorings of 110m and of lateral moorings of 80m, the mooring anchors will lie around the perimeter of a seabed area of 640m x 300m, or 192,000m^2, that is 19.2 hectares or 45% of the proposed licensed seabed area. Axial mooring anchors will weigh 1,500kg each and lateral mooring anchors 1,000kg each

The delineation of a mooring rectangle on the seabed infers no claim whatever on ownership or rights of entry to the area. In fact, such is the small size of mooring anchors on salmon farm sites that it is normal practice for inshore fishing activities to continue within the seabed mooring area.

The cage nets for the Shot Head site will be 15m deep, giving an individual cage volume of some 20,000m^3 and a total cage volume for 12 cages of 240,000m^3. See Section 3.3.2. for further details on cage volume and use.

A feed barge will be deployed on the shoreward, most sheltered side of the site; see Figure 4. The feed barge will be used to feed the stock automatically throughout daylight hours and, thereby, to optimise feed conversion (see Section 3.1) and to minimise waste. The amount of feed fed to each cage is measured using an onboard, computerised farm management and feed dosing system. The feed is delivered to each cage individually via a pipe distribution system using compressed air. The barge type is expected to be an AKVA RH2000 type, with a length of 21.5m and a beam of 7.5. Total feed capacity of the barge will comprise four hoppers holding 200 tonnes of feed.

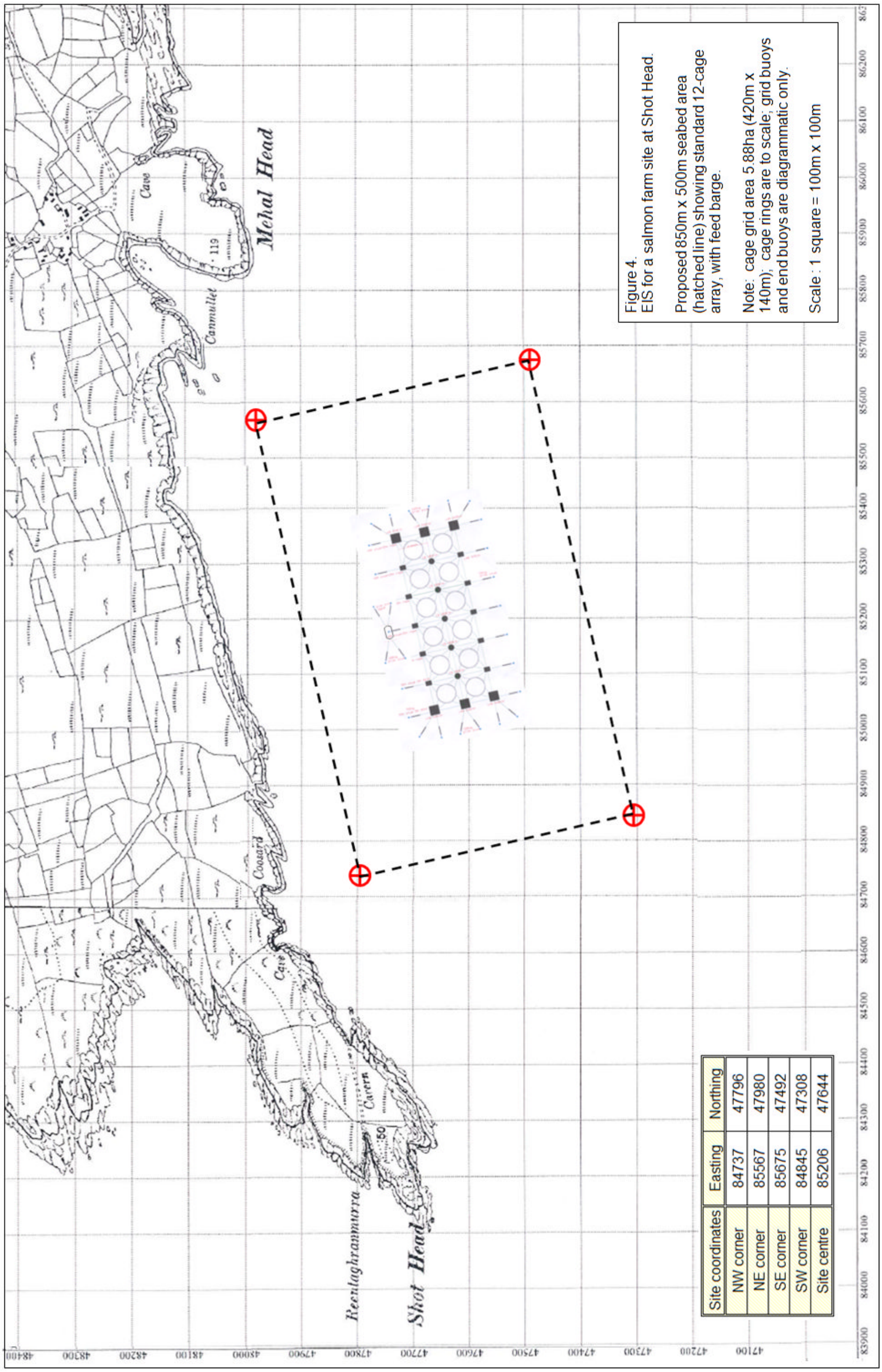


Figure 4.
EIS for a salmon farm site at Shot Head.

Site coordinates	Easting	Northing
NW corner	84737	47796
NE corner	85567	47980
SE corner	85675	47492
SW corner	84845	47308
Site centre	85206	47644

1.7. Scoping.

A scoping letter was circulated to a total of 65 parties prior to the commencement of the EIA. The scoping letter, address list, responses and analysis can be found in Appendix 1. Responses came from 15 (22.4%) parties, of which two were not circulated at the outset but were added to the circulation list during the scoping process (thus total number of scopees 67).

Judging by experience over the last 15 years or so, the scoping response rate in this case was low. Response rate for salmon farm applications is normally 33% or more and can even exceed the total number of scoping letters circulated. Generally however, high response rates are either orchestrated or are focussed on a particular concern. This did not occur on this occasion. This may be due to the quite isolated and obscured location of the site or may be a result of a familiarity with aquaculture activity in Bantry Bay. Nonetheless, the replies received are regarded as important and relevant to this EIS

The scoping address list comprised 22 statutory consultees, 18 professional bodies and other associations including charities, 8 local and national politicians, 14 business and commercial interests and three private individuals and other private interests. The last category was short because the site area is isolated and not visible to any permanent resident.

Responses were received from 6 (27.2% of the category) statutory consultees, 2 (16.7% of the category) professional bodies and other associations including charities; no local or national politicians responded, whilst 5 (35.7% of the category) business and commercial interests and two (66.7% of the category) private individuals and other interested parties responded.

Of the 15 responses received, 5 (33.3% of responses) were acknowledgments of receipt with no relevant comment, 1 (6.7% of responses) was in favour for reasons given (employment), 2 (16.7% of responses) had concerns about fishing grounds (one of these from a local fishery organisation representing a number of local fishermen), 1 (6.7% of responses) was concerned with environmental and compliance issues and 6 (40.0% of responses) dwelt on navigational and access issues, three of which, from Tarmac Fleming (Quarry at Leahill), Conoco Philips (Bantry Bay Terminal Whiddy Island), and Bantry Bay Pilotage, concerned limitation of the sea area for navigation for large vessels, principally oil tankers and bulk carriers.

The opinions expressed in the scoping responses have all been taken into account in the EIS document. Issues on which respondents requested detail have been examined and reasons given for support or opposition to the project have been analysed in the appropriate sections of this document.

Section 2.
Site location and characteristics.

2.1 General characteristics.

2.1.1. Geography and natural features

Bantry Bay is bounded by the Beara Peninsula to its north, and the Sheep's Head, (or Muintivara Peninsula), to its south. There is a backbone of hills and mountains along the length of the Beara Peninsula. The Slieve Miskish and Caha Mountains form its main spine, peaking at Hungry Hill (685m). The Sheep's Head Peninsula is much narrower than the Beara Peninsula and less mountainous, peaking at about 350m. Its narrow width is more steeply sloped for the most part from its ridge down to the shoreline of the bay than the Beara Peninsula. The bay runs some 39km on a west-south-westerly axis from the town of Bantry at its head to the open sea. It varies in width from 3km at the eastern end to 9km towards its mouth. It is thus fully open to prevailing (west to south westerly) conditions, from the Atlantic.

The mountainous, peninsular topography and low rock permeability of both peninsulae dictate that there are no significant rivers on the Sheep's Head Peninsula and only a small number on Beara. However the high rainfall in the area serves many small rivers and streams, which tend to run low in summer and are prone to spate during prolonged rainfall, which mainly occurs during winter. The only rivers of note drain of the Beara Peninsula into Bantry Bay, namely the Clashduff / Adrigole River, the Glengarriff River, both of which drain from the Caha Mountains, the Coomhola River, which passes down the Borlin Valley and the Owvane River, which both enter the bay close to Ballylickey, and the Mealagh River, which enters the sea via the Donemark Falls, just North of Bantry town. These three rivers between them are the main drainage for the eastern end of the Bantry Bay catchment. All five of these rivers are recognised as salmon producers by the National Salmon Commission and were the main contributors of stock to the considerable Bantry Bay drift net catch in years gone by.

2.1.2. Biology and conservation

West Cork is well endowed with areas deemed worthy of conservation for a variety of reasons. The National Parks and Wildlife Service (NPWS), a division of the Department of the Environment, Heritage and Local Government, is responsible for the designation of areas deemed worthy of protection under a number of headings. National

Heritage Areas (NHA's), and Special Areas of Conservation (SAC's) are areas that meet criteria set down in the EU "Habitats Directive", 92/43/EEC. Special Protection Areas (SPA's) are areas designated for protection under the EU "Wild Birds Directive", 79/409/EEC. All the SAC's and SPA's in Europe are grouped into the "Natura 2000" network under the Habitats Directive and are fully protected in Irish law. Synopses and maps for all protected and designated areas relevant to this EIS can be found in Appendix 6.

Unlike a number of loughs and bays around the Irish coast, the waters of Bantry Bay are not, as a whole, protected under any conservation designation. However expanses of the shoreline and hinterland are. The Beara Peninsula SPA, 004155, covers sea cliffs, the land adjacent to the cliff edge and a number of upland areas at the western end of the peninsula, from Cod's Head in Kenmare Bay to the southern shore of Bear Island in outer Bantry Bay. The special conservation interest is primarily for breeding populations of the bird species Chough (a red book species), Fulmar and Peregrine, amongst others. Both Chough and Peregrine are listed in Annexe 1 of the EU Birds Directive.

The western end of the Sheep's Head Peninsula is also protected, both by the Sheep's Head to Toe Head SPA, 004156, for much the same range of species that inhabit the sea cliffs and upland areas in the Beara Peninsula SPA, and by the Sheep's Head SAC 000102, where the interest lies in the presence of a number of notable plant species, within dry and wet heath habitats, which are both listed as Annex II habitats of the Habitats Directive. The Annex II species, the Kerry Slug, *Geomalacus maculosis* is also known from this site.

The Glengarriff Harbour and Woodland SAC, 000090, is mainly designated for its Oceanic Sessile oak / holly woodland, being second only to Killarney as typifying this habitat. However the SAC also covers the largest colony of Common Seals (*Phoca vitulina*) in south-west Ireland, which occupy a number of seasonal haul-outs in Glengarriff Harbour. Part of the woodland area at Glengarriff was designated a Nature Reserve in 1991 and is now owned and managed by NPWS, primarily for conservation and amenity purposes.

The only coastal areas protected around Bantry Bay are the western ends of the Beara and Sheep's Head Peninsulae and Glengarriff Harbour. However there are numerous inshore and upland designated areas, including the blanket bogs at Hungry Hill (NHA 001059) and Pulleen Harbour (NHA 002416), Trafrask (NHA 002371) and Leahill

(NHA 002417), all on Beara. In fact the Leahill Bog and Trafrask Bog NHA's are the nearest protected areas to the proposed Shot Head site. Blanket Bog is an EU Habitats Directive Annex I priority habitat.

The Caha Mountains, which form the spine of much of the Beara Peninsula, are a designated SAC area (SAC 000093). It is designated primarily for large areas of blanket bog but also for other Annex I habitats, including alpine heath, siliceous rocks and scree, oligotrophic and dystrophic lakes and wet heath. Interesting plant species within the site include the Killarney Fern (*Trichomanes speciosum*) and the only known population of the Recurved Sandwort (*Minuartia recurva*) in Britain and Ireland. Both species are listed in the Irish Red Data Book and are legally protected under the Flora Protection Order 1987. Of animal species, the Kerry Slug and the Otter (Annex II Habitats Directive species), the Irish Hare, common lizard, frog and brown trout are of interest, along with Peregrine Falcon, Hen Harrier, the Chough and the migratory Ring Ouzel, which are all Annexe I Bird Directive species and listed in the Irish Red Data Book.

In addition to the designated areas summarised above, there are some 12 proposed NHAs (pNHA's), around Bantry Bay. Details of these were published along with all the other pNHA's in the country (some 630 altogether) on a non-statutory basis in 1995, but have not since been statutorily proposed or designated. These sites are of significance for wildlife and habitats and designation will proceed on a phased basis over the coming years. These sites include Glengarriff Harbour and Woodland (pNHA 000090), Orthon's Island (pNHA 001028) in Adrigole Harbour, some 5km west of the proposed Shot Head site area and Sheelane Island, (pNHA 001977), some 5km east Shot Head.

In addition to the measures taken to protect the natural environment listed above, there are five Designated Shellfish Areas in Bantry Bay, designated under the Quality of Shellfish Waters Regulations 2006 (SI 268 of 2006) and Article 5 of EU Shellfish Directive, 2006/113/EC. The overriding majority of aquaculture licences for the growing of shellfish in Bantry Bay lie within these areas; see Figures 6 to 8.

One requirement of an EIS is to qualify any possible impact of the proposed operation on local protected areas. Bearing in mind the distance of the site from the few designated coastal areas in Bantry Bay, it is felt unlikely the any such impacts could occur. In respect of Designated Shellfish Areas, this view is further qualified in the relevant Characterisation Report and Pollution Reduction Program Report for each of these areas, published in 2010. The topic of designation and protection is covered in further detail in Section 5.

2.1.3 Population[4]

The population of the Bantry Rural Area, which covers the eastern end of Bantry Bay and the Sheep's Head peninsula, grew from 8,684 to 9,234 between 2002 and 2006, due to small increases in almost all Divisional Electoral Districts. However the population of the Castletown Rural Area, which covers the bulk of the Beara peninsula, shrank from 4,192 to 4,147 in the period, due to slight reductions in the majority of Divisional Electoral Districts. There were 3,356 households in the Bantry Rural area and 1,575 on Beara in 2006. Castletownbere is one of the two main towns on Bantry Bay, with a population of about 868[5], with a further 1,000 living within a 15km catchment. Bantry has a population of about 3,309[6], and a further 12,500 or so living within its catchment. Emigration, in particular to the US and UK has been a major feature of the demographic history of the area, although there has also been some inward migration of Europeans over the last 40 years or so, including some economic migrants from Eastern Europe in the last few years. The current economic climate has raised the issue of emigration again.

2.1.4 Economy and employment[7]

In 2006, there were a total of 2,757 people employed in the 14 Divisional Electoral Districts in the Bantry Rural Area and 1,193 people employed in the seven Divisional Electoral Districts in the Castletown Rural Area. Employment remains below the national average throughout the region. The more vibrant economy to the east of the country is not reflected in relatively remote rural coastal areas, although the EU upgraded their status in the last decade.

The most important occupations in the West Cork region are resource-based, being primarily agriculture, the capture fishery, aquaculture and tourism[8]. The most widespread use of land in the Bantry Bay area is accounted for by agriculture, which employs about 20% of the local population. Dependence on agriculture is marginally above the national average, although farm size is substantially below the national average, being less than 20 hectares, except in some upland areas. The terrain is such that possible uses for agricultural land are very

4 Data source CSO.
5 2006 census data.
6 2006 census data.
7 Data source CSO.
8 Cork County Plan.

limited. Grassland is the major agricultural resource, for the production of cattle, milk, and sheep. In the year 2000, the latest dataset available, there were a total of 34,268 cattle and 103,571 sheep on the Castletown Rural District and Bantry Rural District combined.

The economy of the western end of the Beara peninsula is dominated by fisheries activities, mainly centred in Castletownbere and Dinish Island, see Figure 5. Castletownbere is the primary whitefish port and the second largest fishing port in the country in terms of catch value, due to its landings of white fish and shellfish. Total catch value to Irish vessels in 2007 was €13.33M; see Table 1[9]. As with other fishery ports in the country, despite the surge in 2007, landings have been shrinking in recent years and have fallen by as much as 30% in value in the last decade. An inshore fleet, comprising vessels of under 10m, also operates in Bantry Bay, based mainly in Castletownbere, Glengarriff and Bantry and at the small pier at Leehanebeg, some 14km west of Castletownbere. There is a fuller account of the Bantry Bay Inshore fishery in Section 6.2.

Figure 5.
EIS for a salmon farm site at Shot Head.

Aerial view of Castletownbere Port and Dinish Island, showing fishing vessels tied up at the piers at both locations and the extent of the fisheries / maritime industrial estate on Dinish Island.

Photo source : OSI.

9 Data source; Sea Food Protection Authority (SFPA).

Table 1.
EIS for a salmon farm site at Shot Head.
Summary of fishery statistics for Castletownbere Port.

Type	Landings from Irish vessels tonnes				
	2003	2004	2005	2006	2007
Deepwater	72	28	12	7	40
Demersal	3,361	2,990	2,960	2,721	6,372
Pelagic	1,115	1,979	4,562	3,216	7,569
Shellfish	533	236	343	247	738
Total	5,081	5,233	7,877	6,191	14,719
Value €'000	*8,418*	*7,889*	*8,456*	*9,682*	*13,331*

Type	Landings from foreign vessels tonnes				
	2003	2004	2005	2006	2007
Deepwater	176	141	241	211	200
Demersal	6,483	5,703	5,027	4,696	7,545
Pelagic	15	41	27	23	102
Shellfish	376	404	275	311	282
Total	7,050	6,289	5,570	5,241	8,129

% Foreign	58%	55%	41%	46%	36%

The Castletownbere fleet is operated by the Castletownbere Fishermen's Co-Op, which employs some 75 full and part-time staff, between processing, fuel sales and administration. In 2007, the Co-Operative had 69 members with 40 vessels between them, employing some 220, fishermen, mainly non-nationals. An Bord Iascaigh and trains about 2,000 students per annum for fishermen's competency ticket, safety and aquaculture. BIM also operates an ice plant on Dinish Island

Aquaculture has had a considerable influence on employment and on the fishery resource in the Bantry Bay area in the last thirty years or so and probably shows more growth than any other sector in the locality. Shellfish farming is the dominant activity, with the greatest number of employees, in particular for mussels. There are some 50 shellfish aquaculture licences in the bay. Salmonid farming also has a considerable presence, with four licences, the largest being the MHI grower site at Roancarrig. A second salmon farming company, Fastnet Irish Seafood, has two licensed salmon farm sites to the east of Shot Head, as well as a number of mussel farm licences. Figures 6 to 8 show the locations of licensed aquaculture sites in Bantry Bay.

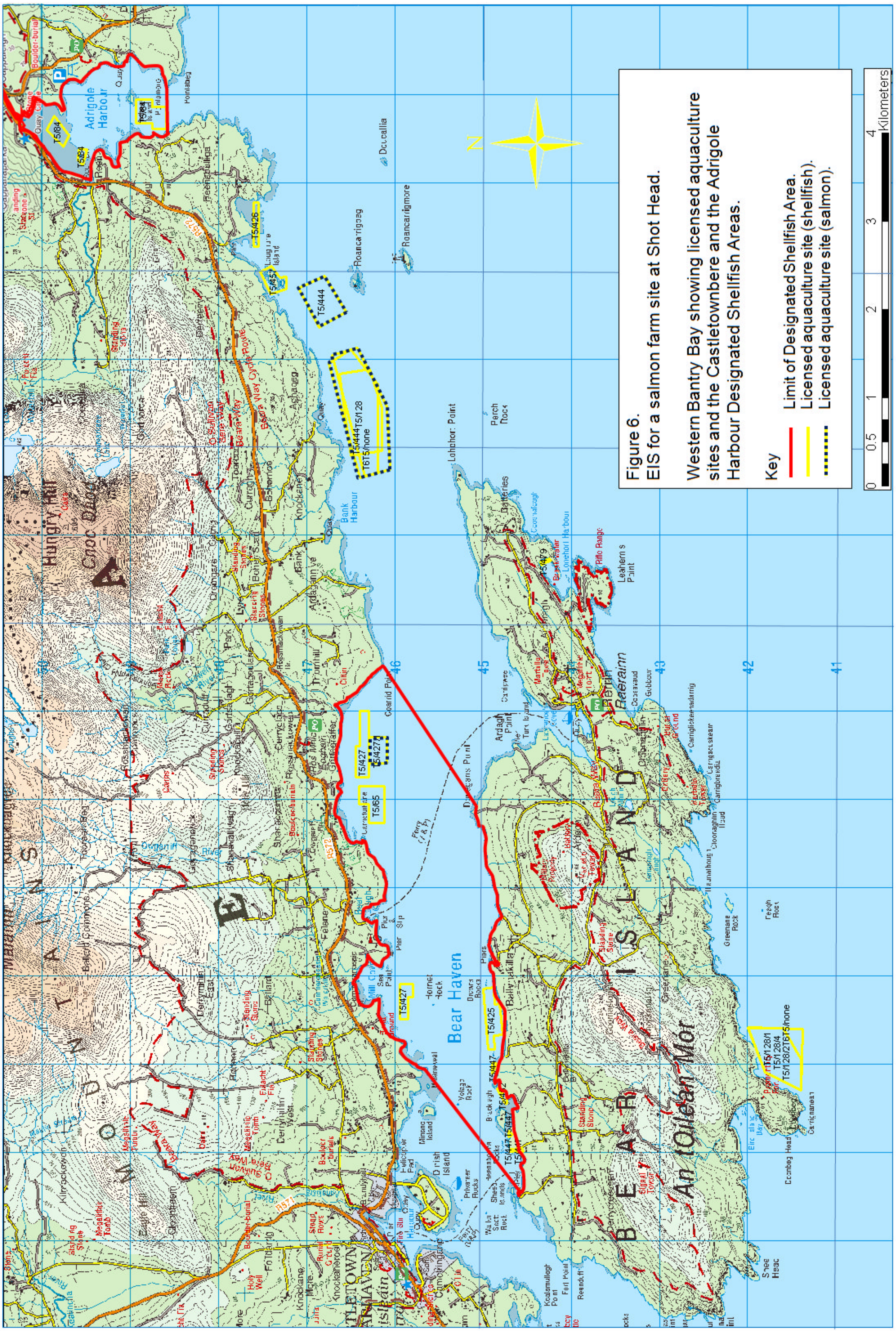


Figure 6.
EIS for a salmon farm site at Shot Head.
Western Bantry Bay showing licensed aquaculture sites and the Castletownbere and the Adrigole Harbour Designated Shellfish Areas.
Key
Limit of Designated Shellfish Area.
Licensed aquaculture site (shellfish).
Licensed aquaculture site (salmon).
Kilometers
0 0.5 1 2 3 4
Bear Haven
Adrigole Harbour
Hungry Hill
Bere Island

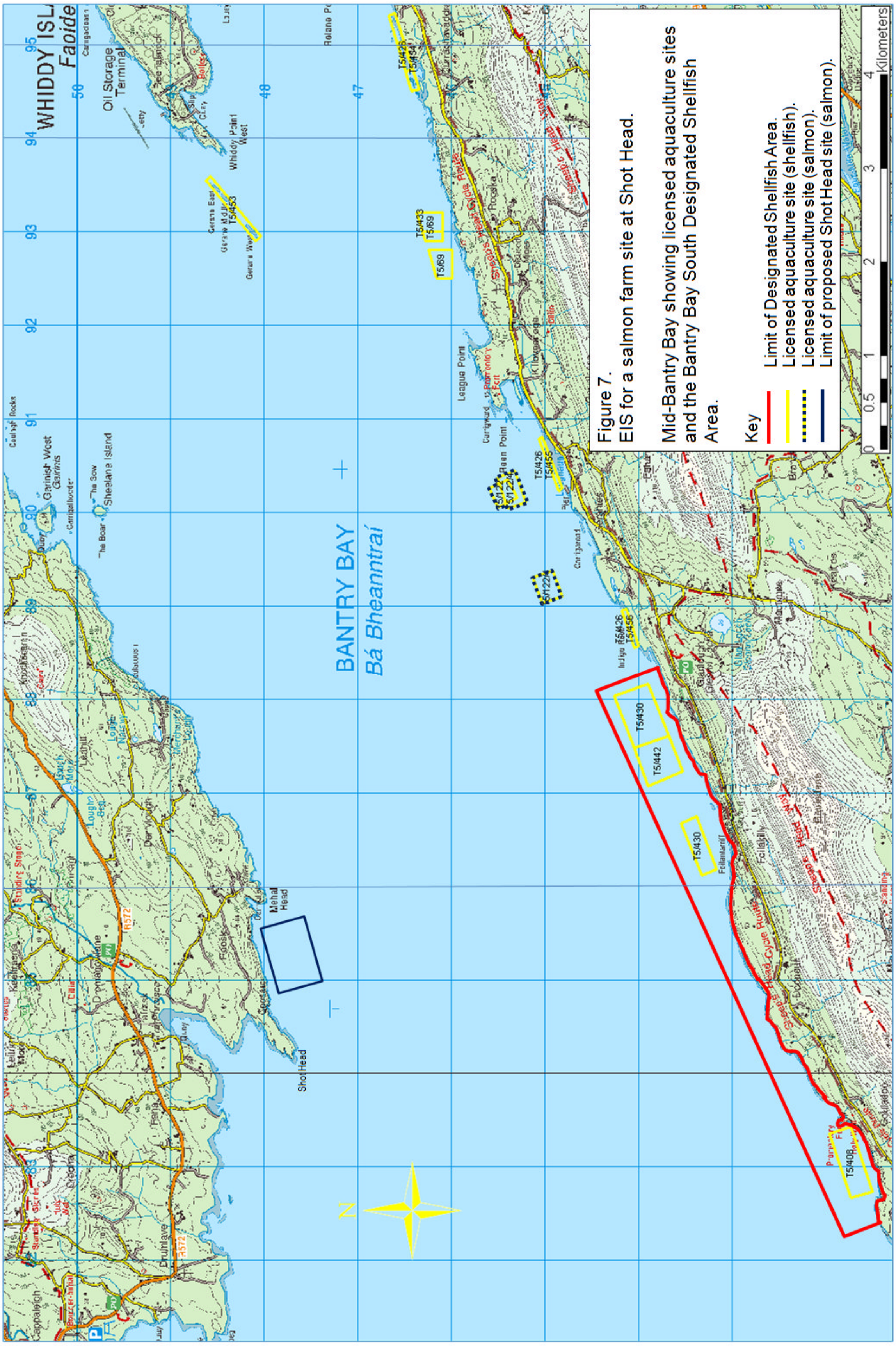


Figure 7.
EIS for a salmon farm site at Shot Head.

Mid-Bantry Bay showing licensed aquaculture sites and the Bantry Bay South Designated Shellfish Area.

Figure 8.
EIS for a salmon farm site at Shot Head.

East end of Bantry Bay, showing licensed aquaculture sites and the Glengarriff Harbour and Bantry Bay Inner Designated Shellfish Areas.

Employment in support services for aquaculture has boosted employment in some areas that already serve the fishing fleet. These include chandlery, net mending, marine engineering and contract services. There is a boatyard with synchrolift and a chandlery, along with two large fish / shellfish processing plants on Dinish Island and two major mussel processing plants south west of Bantry.

The largest single employer in the Castletownbere area is the seafood processor Shellfish de la Mer, with 130 staff. The company has established a 1,800m^2 processing facility on Deenish Island to process shrimp, crab, prawns and other shellfish, sourced both at home and abroad. The company operates a fleet of five 12m day-fishing vessels.

The company Celtic Sea Minerals holds a licence to extract 5,000 tonnes per annum of so-called coral sand from a dead maërl (calcareous red algae) bed off Lonehort Point, at the eastern end of Bear Island. The maërl is extracted using a dredger and is used to manufacture a range of soil conditioners and other products in a processing plant located on Dinish Island, Castletownbere (see Figure 5). The company employs fourteen people in the locality.

There are a variety of other industrial activities, concentrated mainly around Bantry[10]. An oil terminal on Whiddy Island is operated by Bantry Terminals Limited, owned by Conoco Philips, who also operate Ireland's only oil refinery at Whitegate in East Cork. Gulf Oil built the facility as a transhipment terminal, with a capacity of 1.3 million tonnes of oil. Capable of handling the biggest oil tankers in the world when built, with capacities up to 320,000 tonnes dead weight (DWT), the terminal could receive supertankers travelling from the Middle East for transhipment to European refineries in smaller tankers. The construction of the terminal and its operation, with a workforce of up to 250, transformed the economy of Bantry in the 1970's. However the intended future of the Whiddy Oil Terminal was radically changed in 1979 when the oil tanker, the Betelgeuse, exploded and sank while offloading oil at the terminal. This was Ireland's worst industrial disaster, in which fifty French seamen and local workers were killed.

The terminal closed after the disaster but was reopened in 1990 after considerable refurbishment. Up to forty tankers per annum now travel up Bantry Bay to the terminal and up to 45 people have been employed there in recent years. See Figure 9.

[10] Main information source; Bantry Bay Charter

The terminal comprises visible structures covering an area of 75 hectares excluding marine installations. It has a considerable visual impact on the head of the bay and raised some opposition but was justified by its potential benefits to the local and national economy.

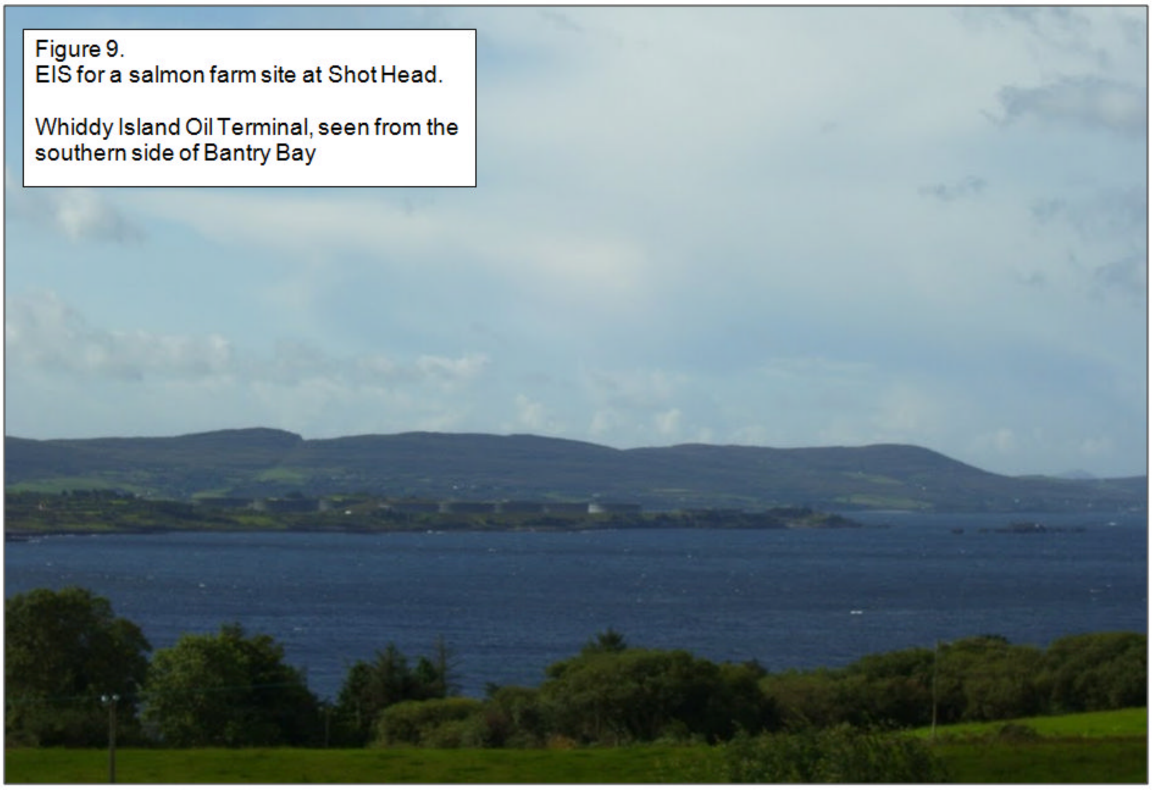


Figure 9.
EIS for a salmon farm site at Shot Head.

Whiddy Island Oil Terminal, seen from the southern side of Bantry Bay

As well as a number of small, privately-owned quarries, Ireland's largest quarry is located on the shoreline at Leahill, 2.5km east of the proposed Shot Head site area; see Figure 10. The quarry is owned by Tarmac Fleming and commenced operations in 1991. THet the quarry is currently closed and seeking a buyer and may or may not return to its former use and output in due course. The quarry covers an area of some 50 hectares and has estimated reserves of 120 million tonnes of quartzite sandstone, used principally in road construction, with major markets in southern England and France. A 120m deep water jetty extension was completed in 1998 which has accommodated bulk vessels of up to 96,000 DWT, which travel up the Bantry Bay main channel, past the proposed Shot Head site, to be loaded.

Rowa Pharmaceuticals was established in Newtown, Bantry in 1979. It has a workforce of up to seventy people and supplies a wide range of prescription, alternative and over-the-counter drugs to over eighty international markets.

Figure 10.
EIS for a salmon farm site at Shot Head.

Leahill quarry, 2.5km east of the proposed Shot Head site.

Source NPWS

Brugmann Ltd is located on the small IDA estate at Drombrow, just outside Bantry. The company began operations in Ireland in 1996. It has a workforce of over thirty and supplies plastic profiles such as uPVC windows, which are marketed in Ireland, Britain and Germany.

Carraigbui Engineering is based in Durrus and supplies specialised pressings and cable and harness assemblies to the computer industry.

There are two major fish and shellfish processing facilities, south of Bantry on the Sheep's Head coastline of Bantry Bay. Bantry Bay Seafoods, who have a 4,200m^2 facility at Gortalassa, employing up to 150 people claim to be Europe's largest processor of rope grown mussels. Fastnet Irish Seafood also have large facility employing some 35 people at Gearhies for the processing of rope grown mussels as well as salmon, from their farming facilities in Bantry Bay.

Further commercial infrastructure, including specialist food producers, hotels, guest houses, banks, supermarkets, builder's providers, pharmacies, clothing retailers, newsagents, souvenir shops, public houses and restaurants and a multi-screen cinema operate in the Bantry Bay area, concentrated mainly in Bantry, Glengarriff and Castletownbere.

2.1.5 Tourism

The Cork Plan regards the Beara Peninsula as relatively lacking in beaches. In the main, beaches around Bantry Bay are small and exposed, comprising coarse grey shingle and stone. There are no Blue Flag beaches within the County Cork.

The importance of hill-walking and similar activities, as well as water-based leisure pursuits, is considered central to future tourism development in the area. To this end, a network of hill paths and appropriate theme-based tourist attractions have been developed in recent years. Recent National Tourism Operational Programs have assisted in the funding of many such leisure activities in the area. The Beara Way walking route, which runs through some of the most scenic coastal and upland areas of the Beara Peninsula, passes within 5km north of the Shot Head site area, at an elevation of about 80m, whilst the Beara Way cycle route passes through Trafrask, along the R572 Castletownbere to Bantry road, about 1km north of the site. However, local topography is such that the site is not visible from either route; see Figure 9. Similar route, known as the Sheep's Head Way and Cycle Way have been established on the Sheep's Head Peninsula; see Figure xx

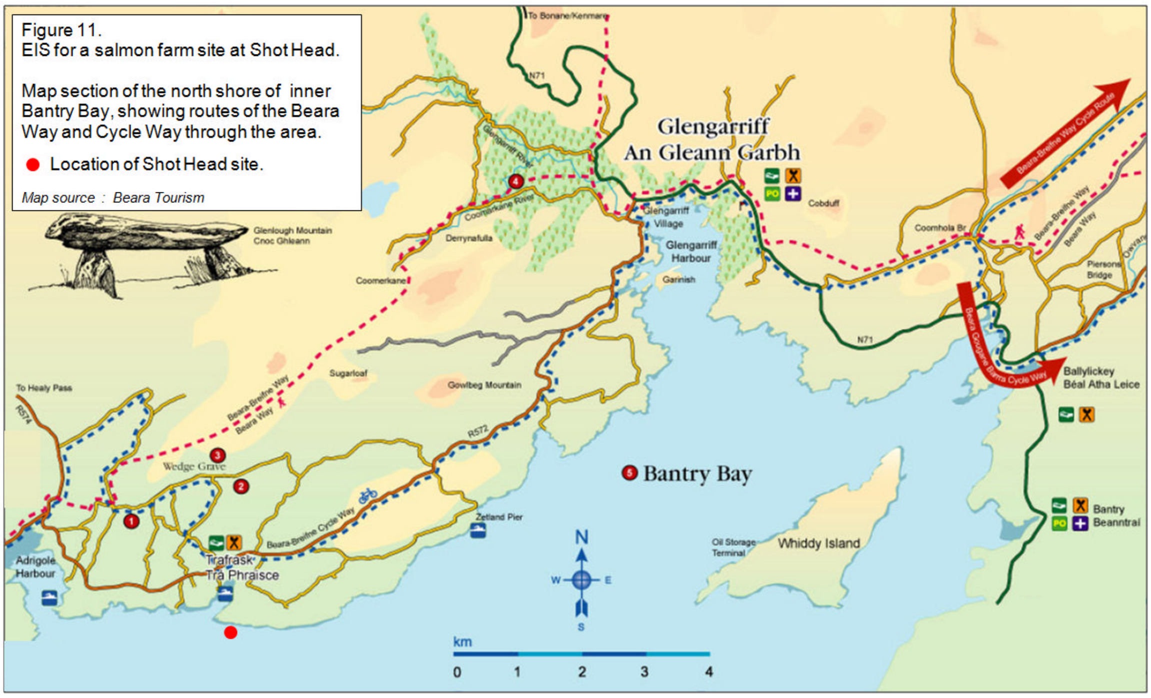


Figure 11.
EIS for a salmon farm site at Shot Head.

Map section of the north shore of inner Bantry Bay, showing routes of the Beara Way and Cycle Way through the area.

● Location of Shot Head site.

Map source : Beara Tourism

Sailing is an established pursuit in Bantry Bay and the Tall Ships Race visited Castletownbere in 1996. Bantry Bay Sailing Club was first established in the late 19th century and now boasts a substantial fleet. The club is a Category 1 affiliate member of the Irish Sailing Association, the national governing body for all forms of recreational and competitive activities involving sail and engine-powered craft in Ireland. There is a yacht marina catering mainly for visiting yachts, at Lawrence Cove, Bere Island. There are also anchorages in Castletownbere, Adrigole, Glengarriff and Bantry Harbours as well as in a small number of other inlets in the bay. The West Cork Sailing and Powerboat Centre is based at Adrigole Pier.

A number of cruise liners anchor in Bantry Inner Harbour each year and contribute to the business of local tourism traders.

Companies offering leisure diving and diving services, including reef and wreck diving and others offering water sports and sea safaris, sea-kayaking and windsurfing operate in both Castletownbere and Bantry. Sea angling, from both the shore and boats is available from a number of centres and a network of shore angling spots has been established around the bay; see Figure 12.

There are a number of key visitor attractions in the Bantry Bay area, notably Bantry House, the Italian Gardens at Garnish Island Glengarriff, Bamboo Park Glengarriff, Glengarriff Wood and the Marine Heritage Centre in Castletownbere.

Tourists to the area spend their overnights in a substantial number of rental properties, many bed and breakfast establishments, camp sites and numerous hotels, in particular in Bantry, Ballylickey, Glengarriff and Castletownbere. There is also a large caravan park and Reen Point, between Bantry and Ballylickey.

Ireland's south-west region of has accommodated the highest number of foreign tourist nights in the country in recent years. Killarney, which has the second highest number of tourist beds in the country after Dublin is the main draw but the scenic quality and ambience of Bantry, Kenmare and Dunmanus Bays and the peninsulae that separate them are another very significant tourist attraction in the region.

It is important for the ongoing development of the local tourist industry that the visual and amenity value and ambience of the area are not compromised by unwise or out of place development. This is a factor that must be taken into account in the development plans for all stakeholders in the area, including the aquaculture industry.

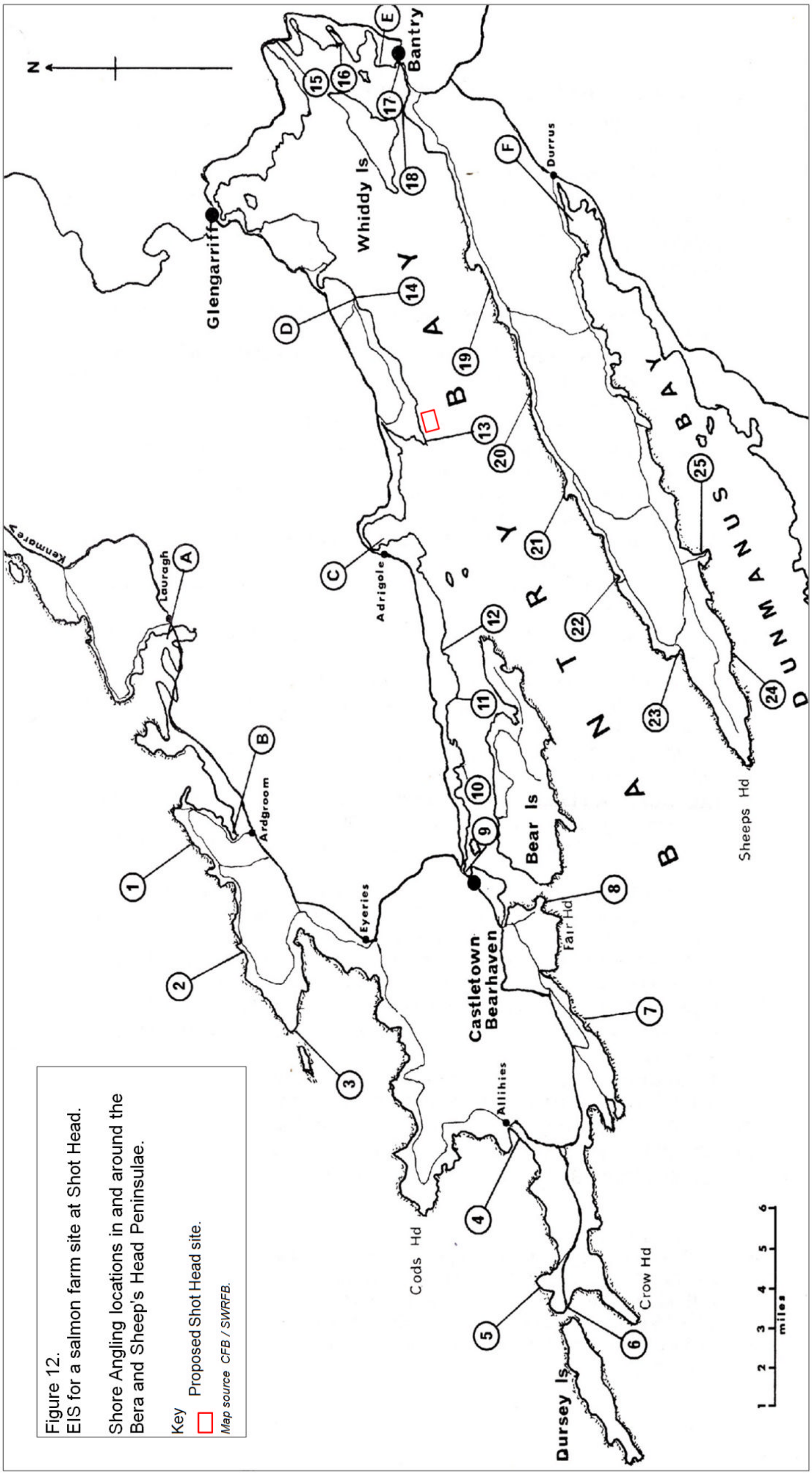


Figure 12.
EIS for a salmon farm site at Shot Head.

Shore Angling locations in and around the Bera and Sheep's Head Peninsulae.

Key
Proposed Shot Head site.
Map source CFB / SWRFB.

2.2. Meteorology

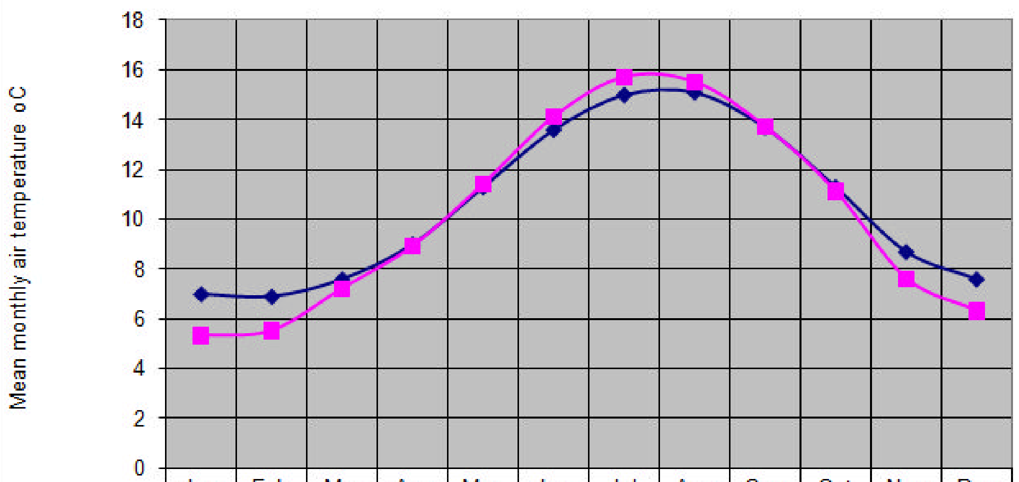
The Gulfstream, which runs up Ireland's west coast, influences ambient air and water temperatures and has a corresponding effect on the local flora and fauna. The climate comprises warm summers and mild winters. Frosts and snow occur infrequently. Historically, long periods of hot summer weather and drought were also rare but have increased in recent years. Extremes of air temperature for the general Bantry Bay area vary from -7ºC (very rarely in January or February) to 30ºC, (very rarely, in July or August). Monthly means vary between 6ºC and 16ºC. Figure 13 gives the 40-year mean monthly air temperature record for the weather stations at Valentia Island and Shannon Airport (55km and 125km north of the proposed Shot Head site respectively).

The southwest is one of the wettest regions of Ireland as shown in Figure 15. Rainfall in the Bantry Bay area is approximately 1,200mm pa at sea level, rising to over 2,000mm pa from 150m above sea level. Some sixty percent of the landmass of the south-western peninsulae is over 150m above sea level. Figure 14 gives mean monthly rainfall for the weather stations at Valentia Island and Shannon Airport. Rainfall is greater in winter than summer months, the rainiest months (December and January having about twice the precipitation of the driest months, which normally fall between April and June.

A wind rose showing offshore winds for the west of Ireland is given in Figure 35. This shows that prevailing winds approach Ireland from south-western quarter, accounting for overt 35% of all winds, blowing from all directions. It is also the quarter from which the highest duration of strongest winds arises. Figure 15 shows the wind frequency data from weather stations across the country. In the southwest, winds blow at over Beaufort Force 4 (5.5 msec^{-1}) for 50% of the time, irrespective of direction. Winds of Force 4-6 (5.5-13.8 msec^{-1}) blow from the south to west for 33% of the time and from the north to east for 16.2% of the time. Winds of over Force 7 (>13.9msec^{-1}) blow for 3% of the time from the south to west and for 1% of the time from north to east. A graph of mean monthly wind speeds for Valentia Island and Shannon Airport are given in Figure 16.

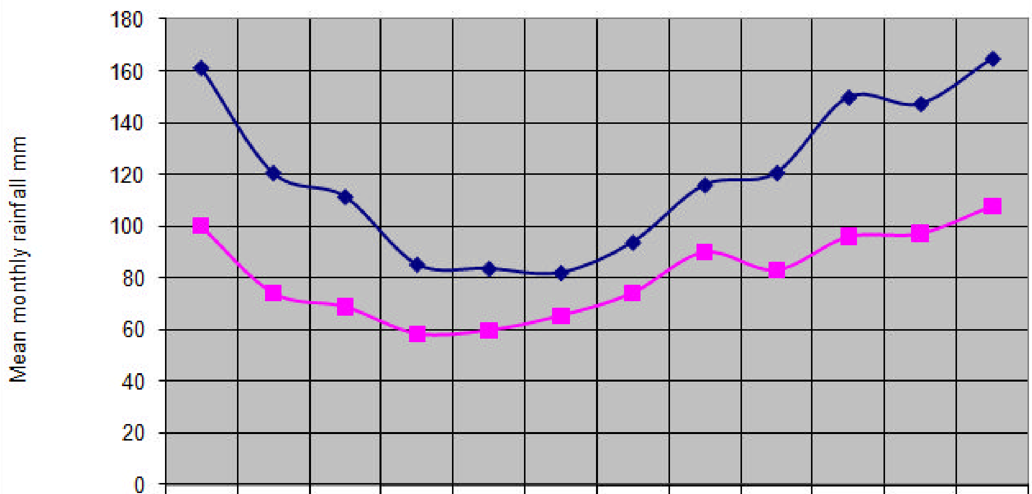
The extreme ambient seawater temperature range for Bantry Bay is from 4ºC (rarely, in January or February) to 23ºC (rarely, between July and September). There is little temperature variation with water depth in the winter months, due to vertical mixing. However, during the summer, a thermocline can develop in deeper areas, giving a vertical temperature gradient between the seabed (cooler) and the surface. The mean monthly seawater temperature range for the Roancarrig site in Bantry Bay is shown for three depths in Figure 17. See also Section 2.6.1 fro ambient seawater temperature data.

Figure 13.
EIS for a salmon farm site near Shot Head.
Monthly mean air temperature °C.
40-year monthly mean; Valentia WS; 51.90°N 10.19°W; 9m above sea level.
40-year monthly mean; Shannon Airport WS; 52.70°N 8.90°W, 14m above sea level.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Valentia	7.0	6.9	7.6	9.0	11.3	13.6	15.0	15.1	13.7	11.3	8.7	7.6
Shannon	5.3	5.5	7.2	8.9	11.4	14.1	15.7	15.5	13.7	11.1	7.6	6.3

Figure 14.
EIS for a salmon farm site near Shot Head.
Rainfall mm.
40-year monthly mean mm; Valentia WS; 51.90°N 10.19°W; 9m above sea level.
40-year monthly mean mm; Shannon Airport WS; 52.70°N 8.90°W, 14m above sea level.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Valentia	161	121	111	85	84	82	94	116	121	150	147	165
Shannon	100	74	69	58	60	65	74	90	83	96	97	108

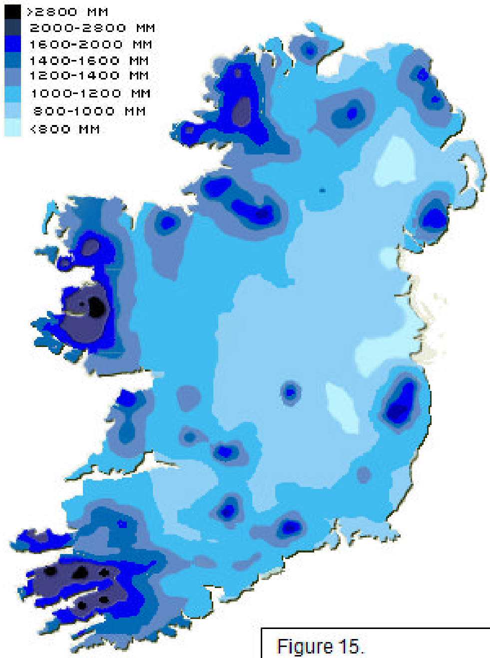


Figure 15.
EIS for a salmon farm site at Shot Head.
Mean monthly rainfall mm.
Source : Met Office.

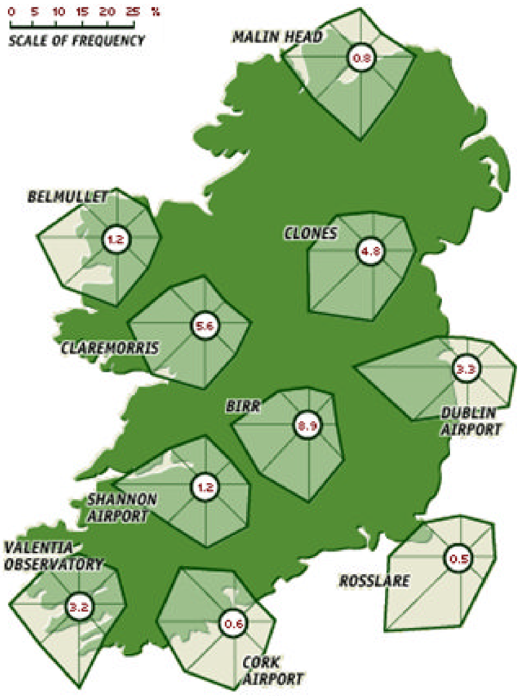
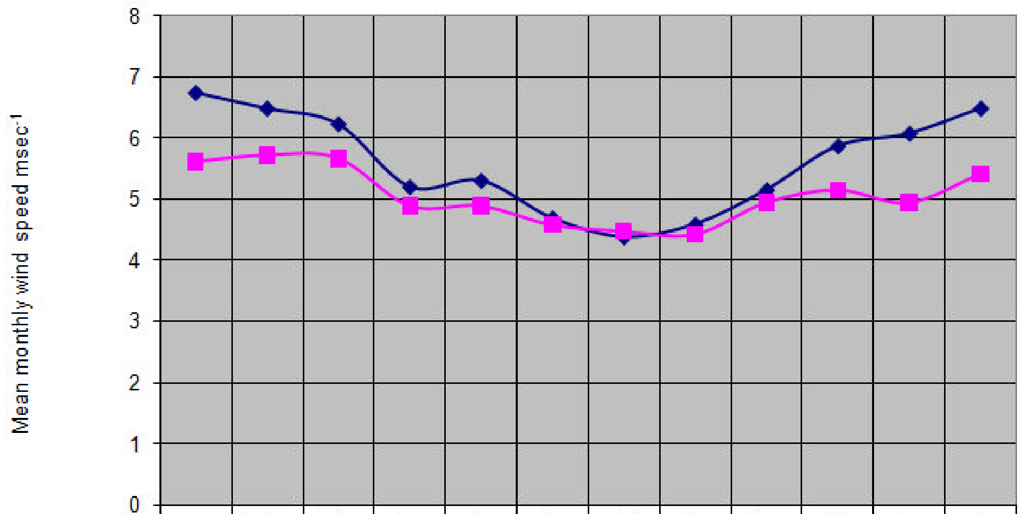


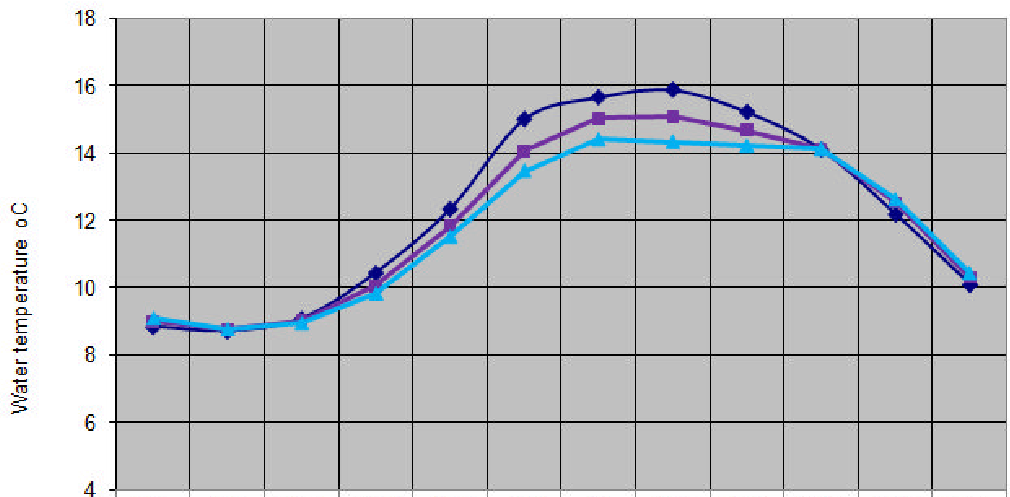
Figure 16.
EIS for a salmon farm site at Shot Head.
Mean monthly frequency % of wind direction.
Note : centre circile : % calm periods.
Source : Met Office.

Figure 17.
EIS for a salmon farm site near Shot Head.
Mean monthly windspeed msec^{-1}
30-year monthly mean; Valentia WS; 51.90°N 10.19°W; 9m above sea level.
30-year monthly mean; Shannon Airport WS; 52.70°N 8.90°W, 14m above sea level.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Valentia	6.74	6.48	6.22	5.20	5.30	4.68	4.37	4.58	5.14	5.86	6.07	6.48
Shannon	5.61	5.71	5.66	4.89	4.89	4.58	4.48	4.42	4.94	5.14	4.94	5.40

Figure 18.
EIS for a salmon farm site near Shot Head.
Mean monthly seawater temperature °C at 1m, 8m and 12m depths.
Roancarrig salmon farm, Bantry Bay, 2006-2010.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
-1m	8.9	8.7	9.1	10.5	12.3	15.0	15.7	15.9	15.2	14.1	12.2	10.1
-8m	9.0	8.8	9.0	10.1	11.8	14.1	15.0	15.1	14.7	14.1	12.5	10.3
-12m	9.1	8.8	9.0	9.8	11.5	13.5	14.4	14.3	14.2	14.1	12.6	10.4

2.3. Hydrography

2.3.1 Bathymetry

The centre of the proposed Shot Head site is approximately 400m seawards of the low water mark as shown in Figure 4. Figure 19, generated as part of the NDP funded Infomar Program[11], shows the bathymetric contours for the eastern end of Bantry Bay, including the area of the Shot Head site. It can be seen that the inner margin of the site lies between the 20m and 30m contours (Lowest Astronomical Tide), whilst the bulk of the site area, including the cages themselves, will lie between the 30m and 40m depth contours. The main channel of Bantry Bay in this area is of a similar depth although it deepens progressively travelling west.

The Infomar project has employed novel means to explore seabed conditions and bathymetry in a number of Irish loughs and bays, including Bantry Bay. The information for the bathymetric image in Figure 19 was gathered using a hull-mounted KS 1002 multibeam echo sounder (MBES). The shallow coastal strip was also covered using aircraft-mounted Light Detection and Ranging (LiDAR) equipment , which uses twin laser beams to penetrate the water column (to about 15m in Irish conditions) to measure depth.

Further information was gathered using the KS 1002MBES, using sunlight from the northwest and northeast to generate a shaded relief images of the seabed in Bantry Bay. The NW image is shown in Figure 20. This indicates a rocky anomaly, scaled to a size of some 100m long and 40m wide, protruding from the seabed more or less in the middle of the proposed Shot Head site area. This rocky areas was encountered during benthic surveying, causing the aborting of a number of grab samples. Approximate depth measurements from the benthic survey vessel indicated that the anomaly protrudes from the seabed by about 4m. It does not represent any hazard to the siting of the farm but may need to be taken into account when shooting moorings.

Tides off the south west coast of Ireland, including in Bantry Bay, are diurnal, with a mean range from MLWS of 3m at spring tides and 1.6m at neap tides. Equinoctial (maximum) tidal ranges approach 4.5m on spring tides and 3.5m on neaps from MLWS.

11 See www.infomar.ie.

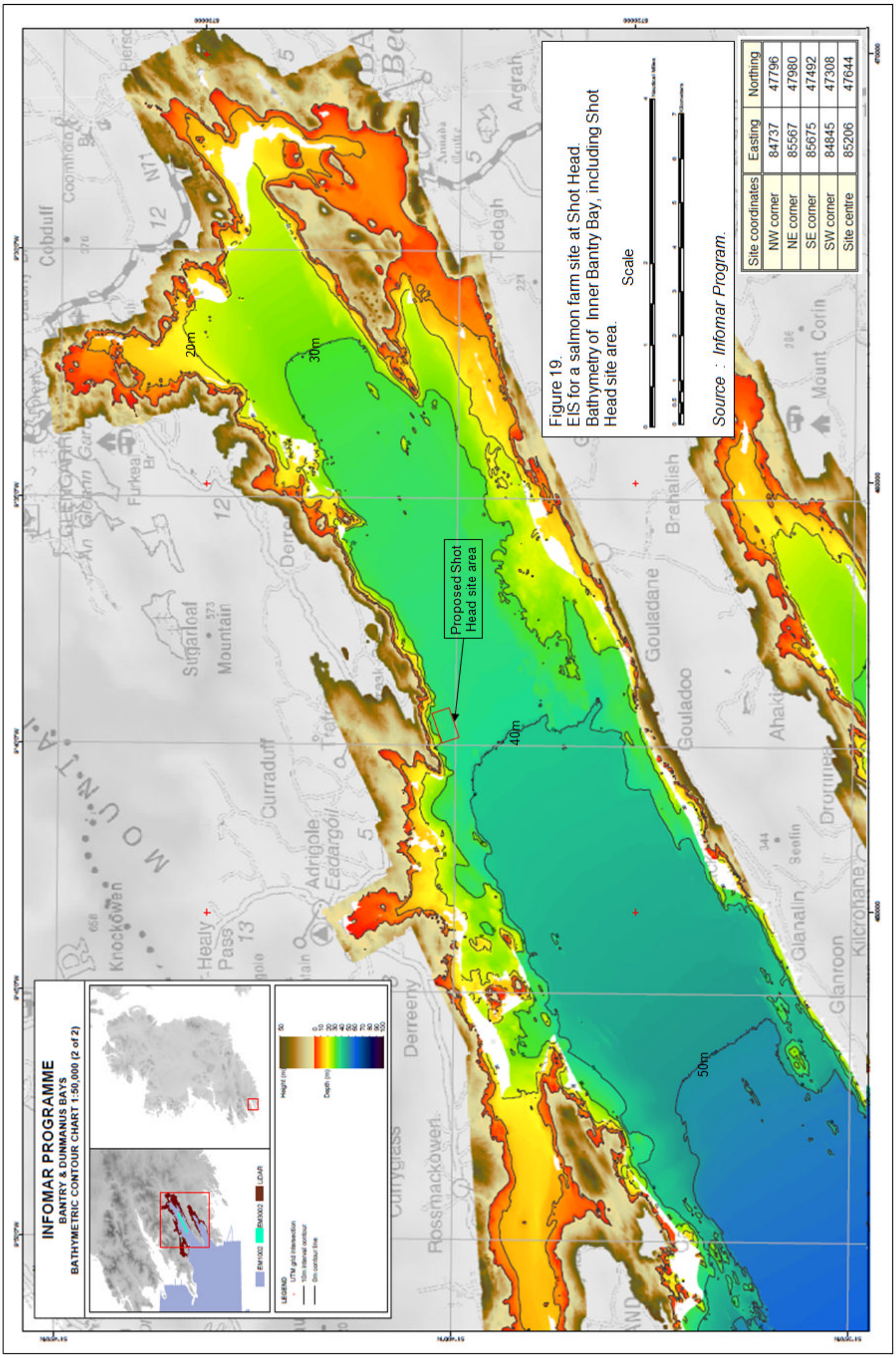


Figure 19.
EIS for a salmon farm site at Shot Head.
Bathymetry of Inner Bantry Bay, including Shot Head site area.

Source : Infomar Program.

Site coordinates	Easting	Northing
NW corner	84737	47796
NE corner	85567	47980
SE corner	85675	47492
SW corner	84845	47308
Site centre	85206	47644

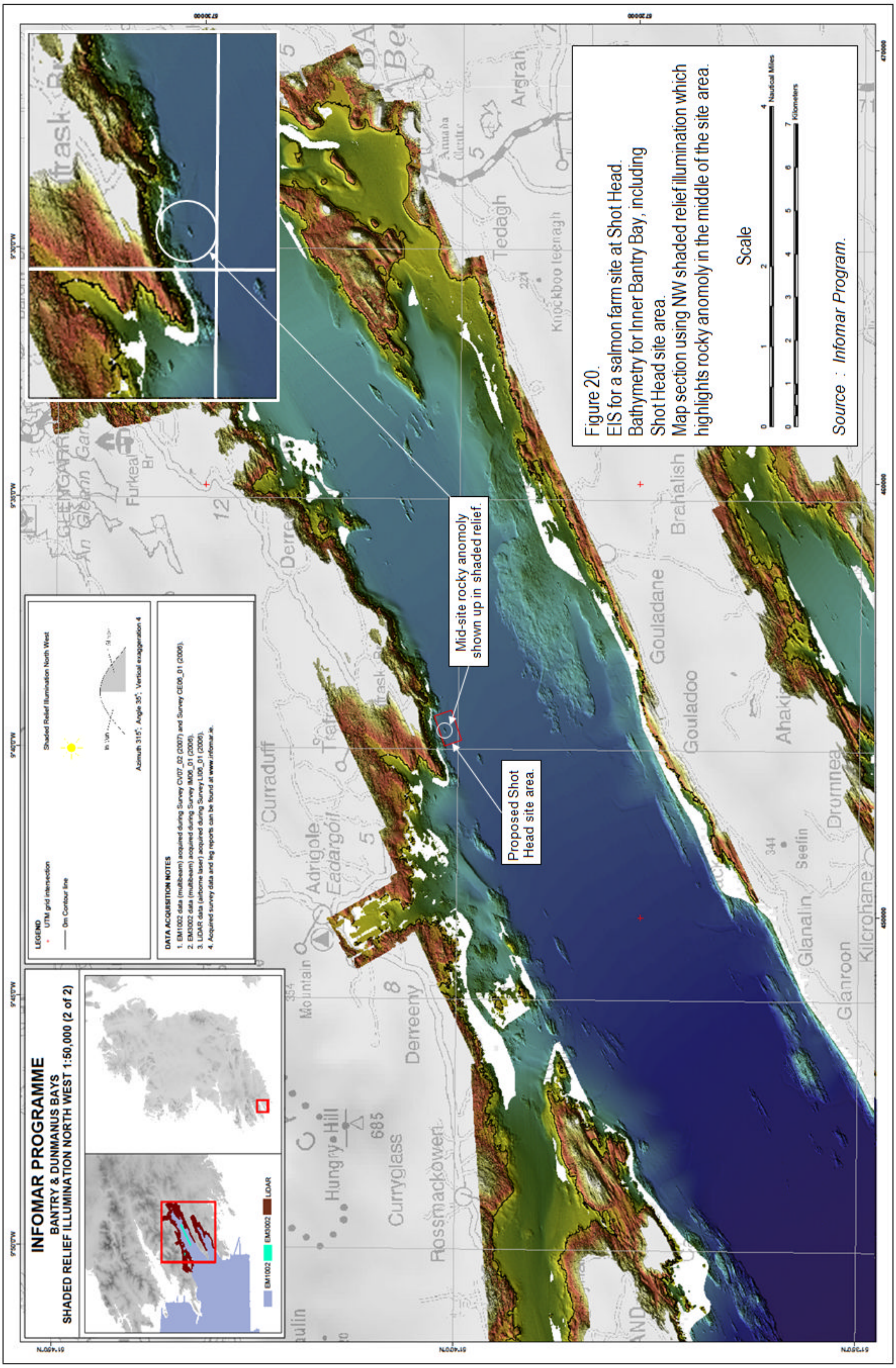


Figure 20.
EIS for a salmon farm site at Shot Head.
Bathymetry for Inner Bantry Bay, including Shot Head site area.
Map section using NW shaded relief illumination which highlights rocky anomoly in the middle of the site area.

Source : Infomar Program.

2.3.2 Currents; hydrographic study

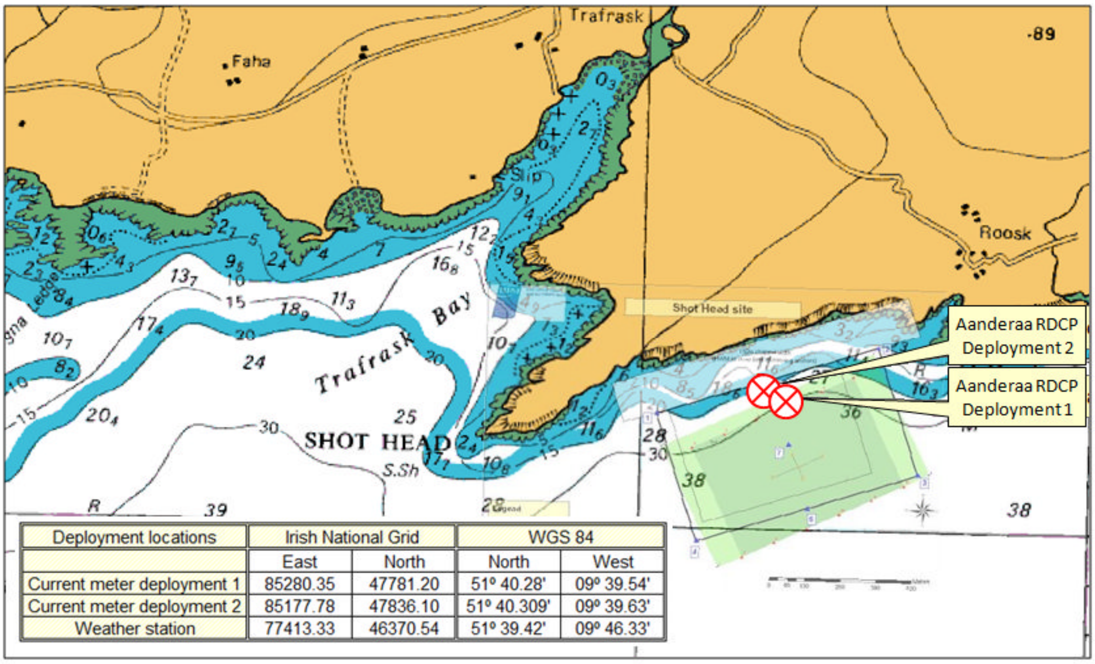
The characteristics of still-weather currents in the area of the proposed Shot Head site were investigated in hydrographic surveys carried out as part of this EIS, during two 15-day periods between 5th and 20th December 2009 and 14th and 29th January 2010. These periods lie on either side of the winter equinox (21st December 2009). The surveys were carried out under the protocol developed by the Scottish Environmental Protection Agency (SEPA) for salmon farm hydrographic surveys. This protocol has been adopted by the Marine Institute and DAFF for hydrographic surveys for finfish aquaculture sites in Ireland[12].

A single Aanderaa RDCP 600 (Recording Doppler Current Profiler) was deployed at the proposed Shot Head site area for each deployment. An automatic weather station was also deployed, on the company's feed barge at the MHI Roancarrig farm site, about 8km west of Shot Head. Wind speed, direction and gust strength were recorded by the weather station, concurrent with recording of water current data. Figure 19 shows the position of the Shot Head site and the deployment positions of the RDCP and gives the deployment coordinates for the RDCP and weather station. Figure 20 depicts the mooring arrangements for the RDCP and the general arrangement of the selectable sensing cells, up through the water column, which record current speed and direction or current vectors in both the horizontal and vertical planes.

Table 1 summarises the findings of the two surveys. The wind blew easterly for much of the first deployment period whereas the prevailing wind conditions on the western Irish coast are westerly. Whilst this did not cause any significant differences in the recorded hydrography between the two deployment periods, conditions during the second period are considered to have been more typical of still weather conditions in the area. This survey was therefore selected for more detailed description in this account.

[12] Regulation and Monitoring of Marine Cage Farming in Scotland; a Procedures Manual. Attachment VIII Site and Hydrographic Survey Requirements. Version 2.7, 31st October 2008. Scottish Environmental Protection Agency. www.sepa.org.

Figure 21.
EIS for a salmon farm site at Shot Head.
Hydrography survey; deployments 1 and 2.
Map of Shot Head, Bantry Bay, showing current meter deployment positions.



Deployment locations	Irish National Grid		WGS 84	
	East	North	North	West
Current meter deployment 1	85280.35	47781.20	51º 40.28'	09º 39.54'
Current meter deployment 2	85177.78	47836.10	51º 40.309'	09º 39.63'
Weather station	77413.33	46370.54	51º 39.42'	09º 46.33'

Figure 22.
EIS for a salmon farm site at Shot Head.
Hydrography survey; deployments 1 and 2.
Diagram of current meter deployment, showing arrangment of data collection cells.

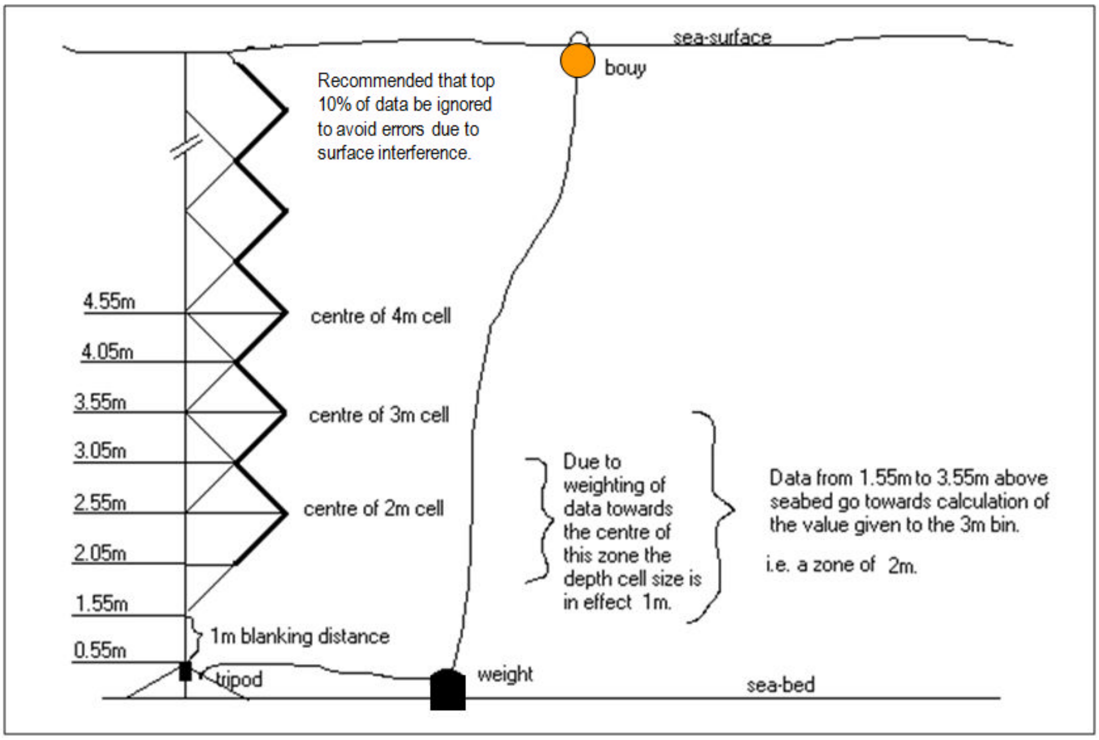


Table 2.
EIS for a salmon farm site at Shot Head.
Hydrography survey; deployments 1 and 2.
Survey summary data.

	Deployment 1			Deployment 2		
Deployment dates (15 days)	00:00 05/10/09 to 00:00 20/12/09			00:00 14/01/10 to 00:00 29/01/10		
RDCP deployment postion ING	85280.35E 47781.20N			85177.78E 47836.10N		
Weather station dep[loyment postion ING	77413.33E 46370.54N			77413.33E 46370.54N		
Highest tide water depth m	38.11			38.17		
Highest tide date	HWS 19:40 GMT 05/12/09			HWS 06:40 GMT 17/01/10		
Lowest tide water depth m	35.00			35.51		
Lowest tide date	LWS 12:20 GMT 05/12/09			LWS 13:00 GMT 17/01/10		
Sensor cell distance from seabed	26m	17m	2m	26.3m	16.4m	2m
Max 3hr rollave current speed cmsec^{-1}	19.40	15.56	11.65	19.19	10.80	9.25
Mean current speed cmsec^{-1}	6.386	5.992	5.005	5.882	4.869	4.985
Mean residual current speed cmsec^{-1}	2.226	2.689	2.161	1.87	1.525	2.495
Total residual distance (15days) m	28,814	34,852	28,006	24,237	19,765	32,331
Mean residual current direction °	302.6°	291.4°	287.3°	273.2°	287.1°	244.8°

Tidal fluctuation was 3.11m (see Table 1; 38.11m - 35.00m) during the first deployment period and 2.66m during the second deployment period. The deployment recording period shown in each case was exactly 15 days, which covers a full tidal cycle, including both spring to neap tides. Tidal fluctuation peaks on the maximum spring tide. The range during deployment period 1 is more than that for deployment period 2 because the first deployment took place in the two weeks leading up to the winter equinox, on December 21st 2009. Deployment 2 took place about 2 weeks after the equinoxial tide. Still weather currents are affected by high and low water depth and this may partially explain the higher mean rolling average currents and residual currents that occurred during deployment 1 (see Table 2) The greatest tidal ranges occur on the spring tides closest to the vernal and autumnal equinoxes, towards the end of March and September respectively, when a tidal range of up to 4m can be expected on the west coast of Ireland. This will be when the greatest flood and ebb still weather currents are likely to be experienced at the Shot Head site. See Figures 23 and 24 for further details on the tidal data record during deployment 2.

Current vector scatter plots and cumulative vector plots for the three sensor depths selected (as distance from seabed) are shown in Figures 25 and 26 respectively. The current vector scatter plot in Figure 25 shows a predominance of vector points in the western segment of the graph, indicating that residual flow is in a broadly westerly direction at all depths, in this section of Bantry Bay.

Figure 23.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Tide height at RDCP station, as water depth to seabed, m.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.

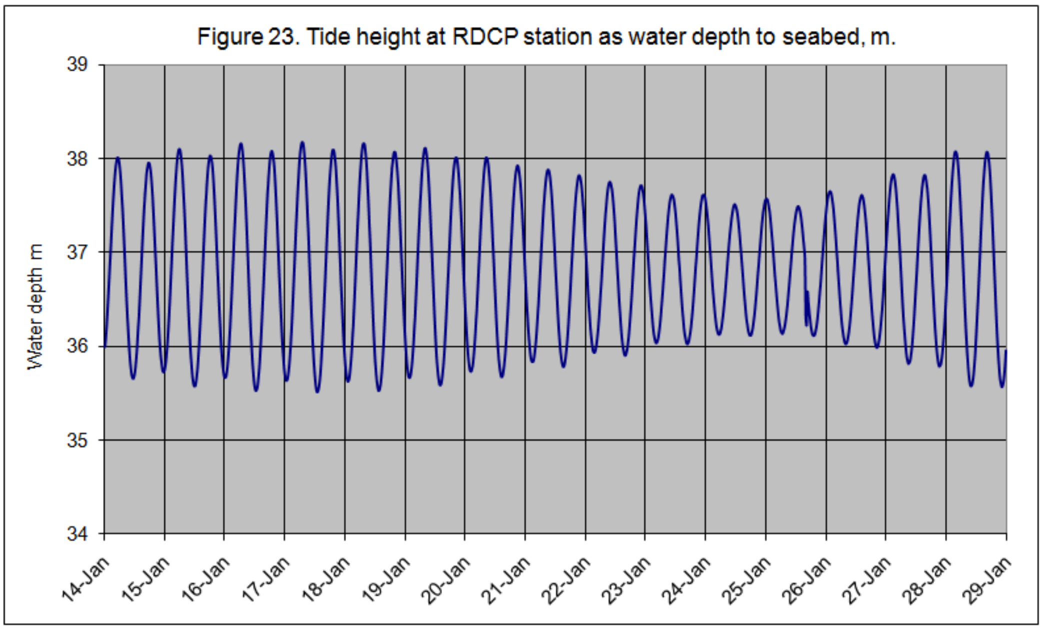


Figure 24.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Variation in depth of RDCP cells from water surface, m, with tidal flux.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.

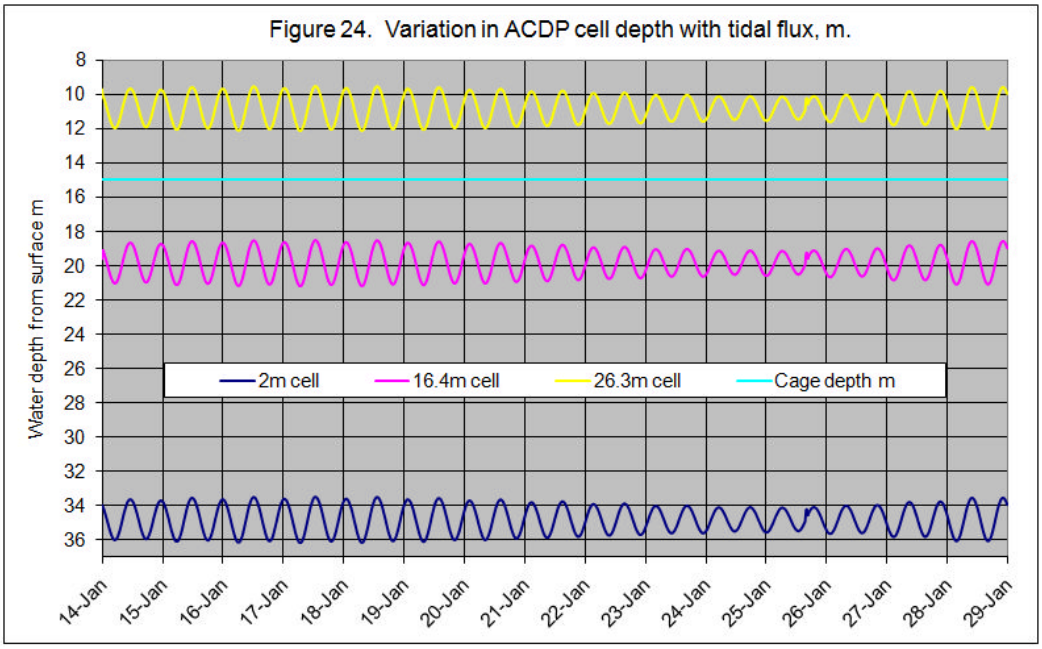
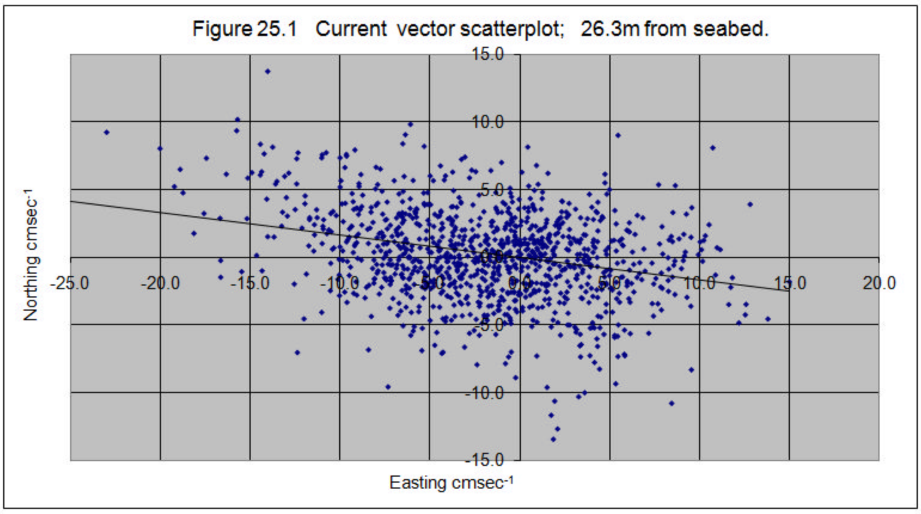


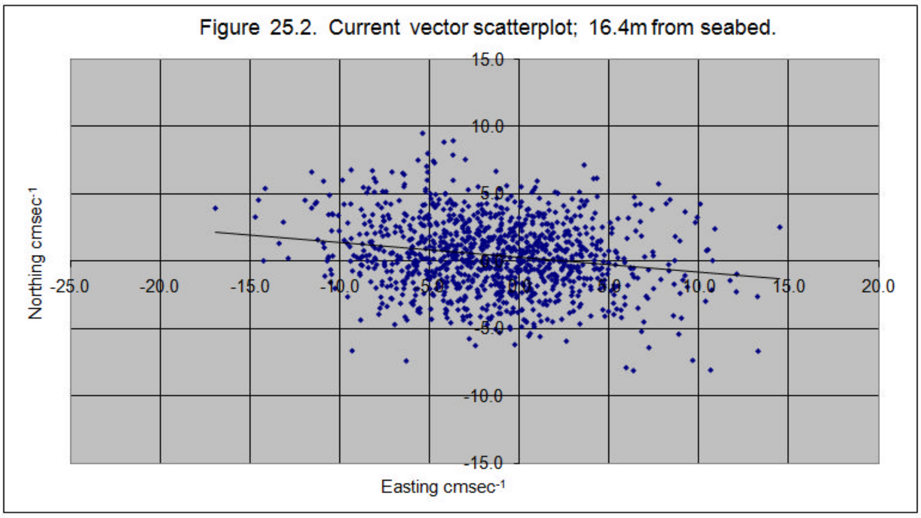
Table 2 and Figure 25 show that the westerly residual current travels west, away from Shot Head at a speed of 1.5 to 2.5cmsec^{-1} (up to 2km per day). Figure 28, of 3-hour rolling averaged currents, shows that sustained currents can peak on the flood and ebb tides at around 10cmsec^{-1} at certain states of the tide. Further, Figure 29 indicates considerable vertical movement in the water column, in the range of +2cmsec^{-1} (near the seabed) to -3cmsec^{-1}. These data suggest that there can be considerable water movement to aid the dispersion and dilution of solutes from the Shot Head site. This subject is investigated further with a simple dilution box model in Section 4.7.

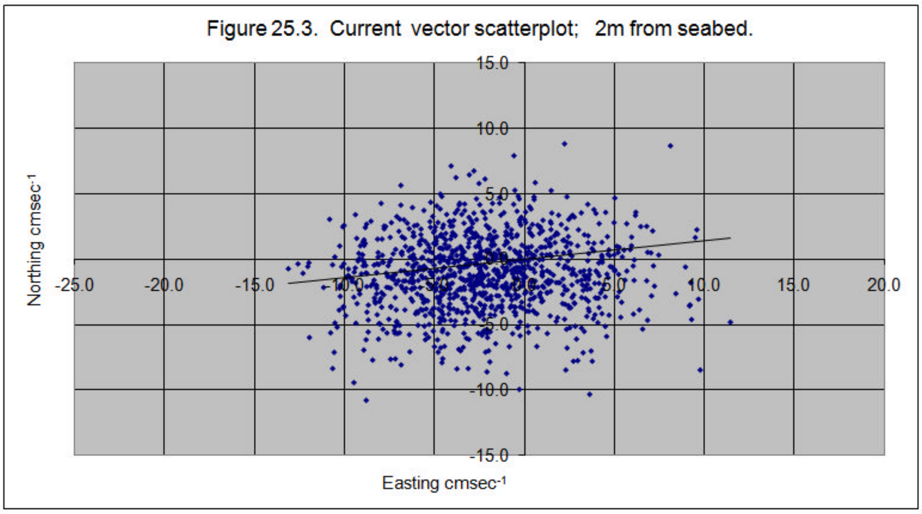
Figure 27 shows the current speed at the three selected depths as well as the association between current speed and tidal state. The figure demonstrates that maximum still-weather current speed coincides with the spring tide period, as expected. Figure 27 also shows that the fastest currents through the Shot Head site occur on the ebb tide, which travels west. The stronger ebb flow causes the overall westerly drift of the residual current from Shot Head, demonstrated in Figures 25 and 26, towards the open sea. These data go towards confirming the characteristics of the current circulation in this part of Bantry Bay, where the flood is stronger than the ebb along the southern shore whilst the ebb is stronger than the flood to the north. This indicates an overall residual current circulation, in this area, running east from the sea along the southern shore and turning west to run seawards through shot head and towards Bear Island. Other hydrography studies carried out by MHI, at the MHI Roancarrig site, have shown that the flood tide passes through Berehaven and through the Roancarrig site. It then turns to the south on the ebb tide, to pass south of Bere Island, to join the circulation travelling west from Shot Head. As a result, any soluble or suspended wastes emanating from both the proposed Shot Head and MHI Roancarrig sites can be expected to pass from the sites, to the south of Bear Island and out into the Atlantic circulation, rather than to circulate within the bay area.

Figure 30 confirms the cumulative vector plots given in Figure 25 in that it can be seen that the frequency of current direction is somewhat bimodal, associated with tidal flux, peaking at roughly 300º (roughly WNW) and 100º (roughly E) at 26.3mm and at 290º and 100º at 16.4m, coming closer to westerly / easterly with depth. The dominant westerly (ebb, see above) mode, at all depths, is clearly the reason for the overall westerly drift shown in the cumulative vector plot, causing waters from the Shot Head area to move west, away from the head of the bay and, ultimately, into the Atlantic circulation.

Figure 25.1 to 25.3.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Scatterplots of current vectors (cmsec⁻¹); at 26.3m, 16.4m and 2.0m from seabed.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.







Figures 26.1 to 26.3.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Current cumulative vector plots (m); at 26.3m, 16.4m and 2.0m from the seabed.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.

Figure 26.1. Current cumulative vector plot; 26.3m from seabed.

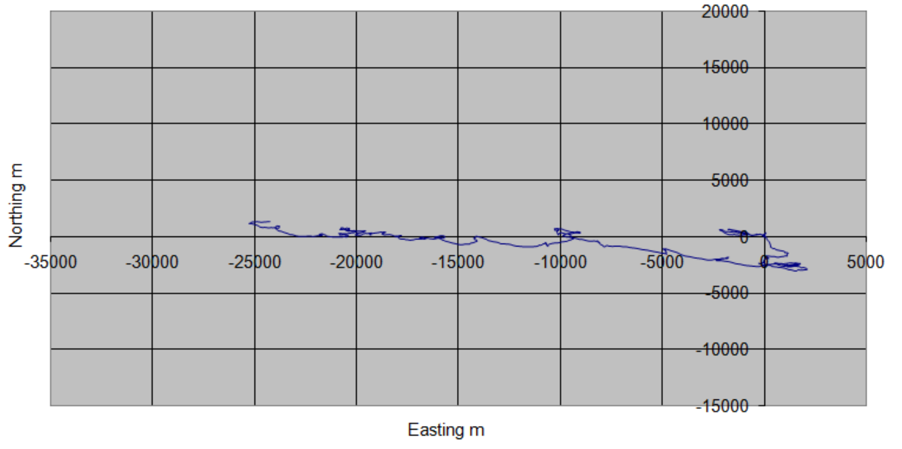


Figure 26.2. Current cumulative vector plot; 16.4m from seabed.

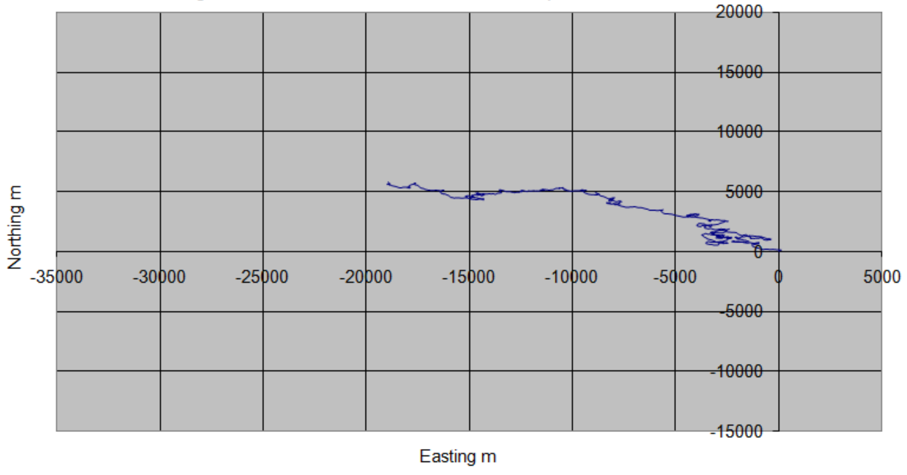


Figure 26.3. Current cumulative vector plot; 2m from seabed.

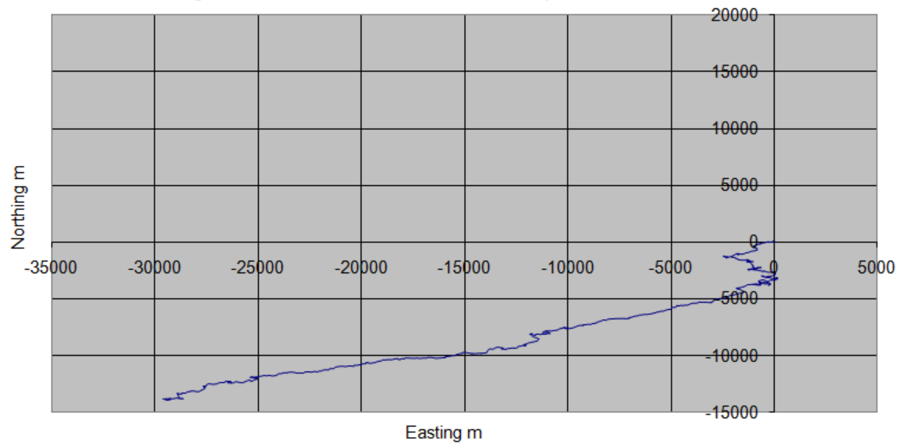


Figure 27.1 to 27.3.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Time series of current speed vs. tidal flux at 26.3m, 16.4m and 2.0m from seabed.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.

Figure 27.1. Time-series of curent speed vs. tidal flux, 26.3 m from seabed.

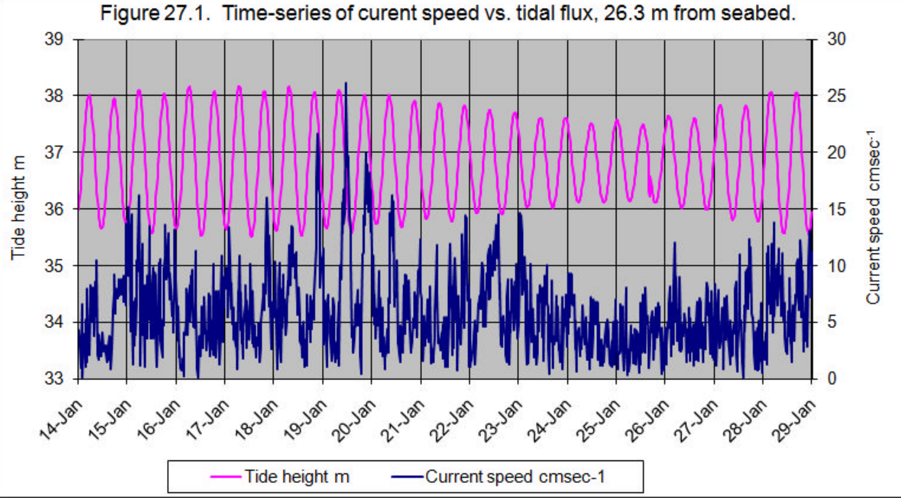


Figure 27.2. Time-series of curent speed vs. tidal flux, 16.4m from seabed.

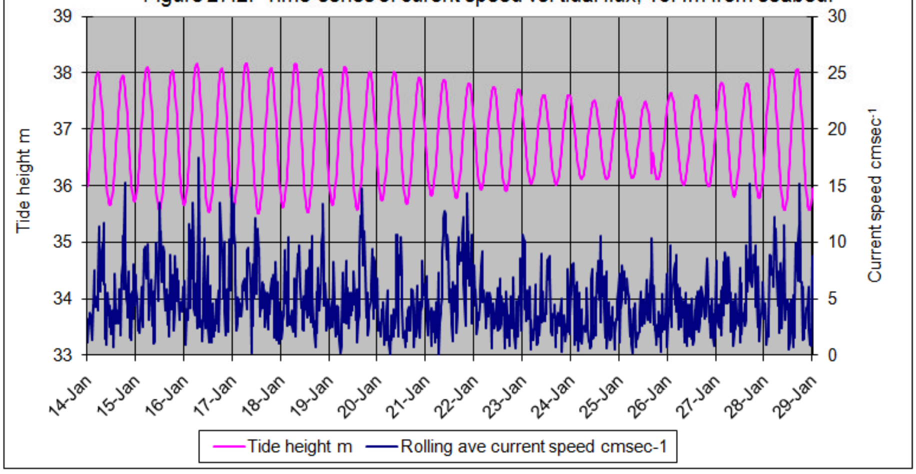


Figure 27.3. Time-series of curent speed vs. tidal flux, 2m from seabed.

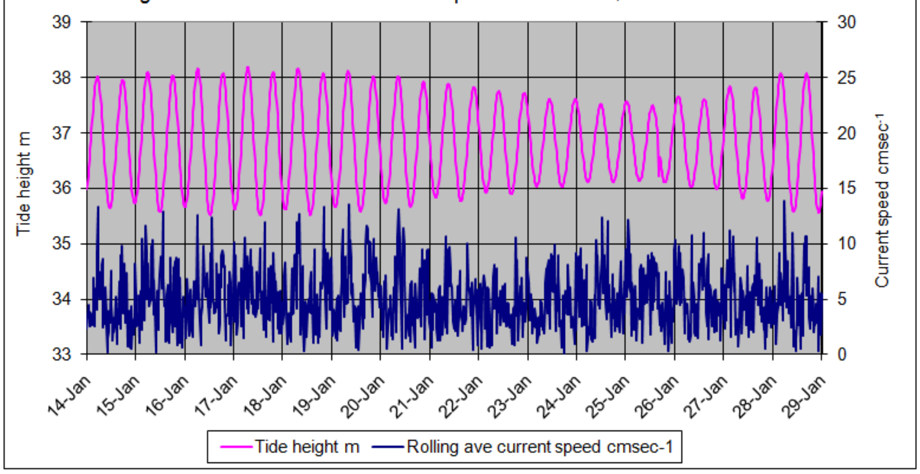


Figure 28.1 to 28.3.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Rolling average current speed (cmsec^{-1}) at 26.3m, 16.4m and 2.0m from seabed.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.

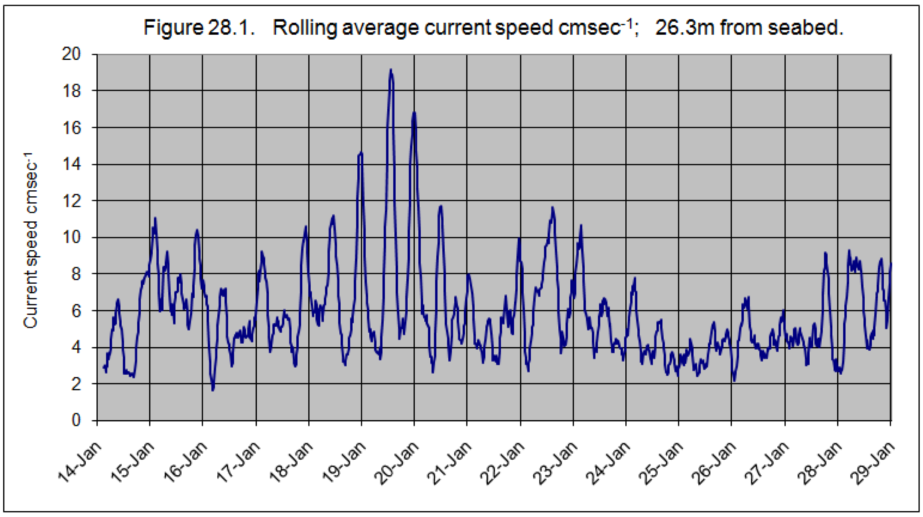


Figure 28.1. Rolling average current speed cmsec^{-1}; 26.3m from seabed.

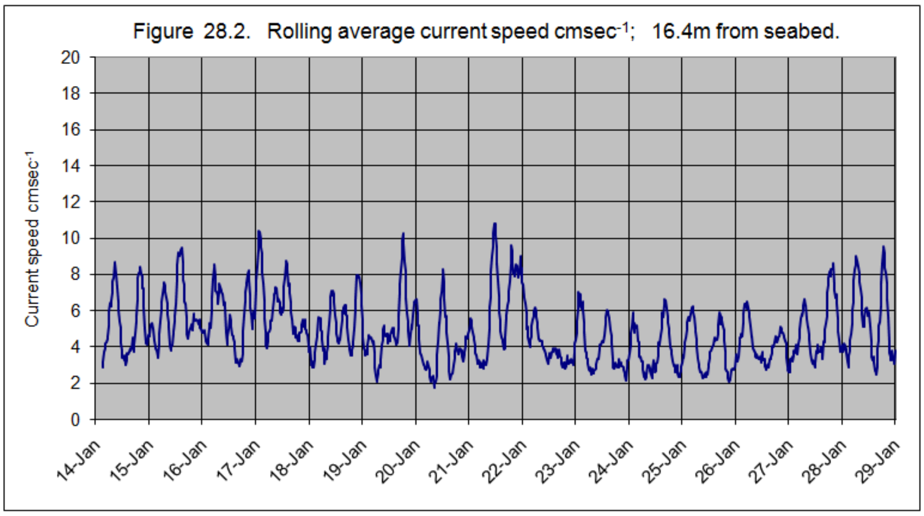


Figure 28.2. Rolling average current speed cmsec^{-1}; 16.4m from seabed.

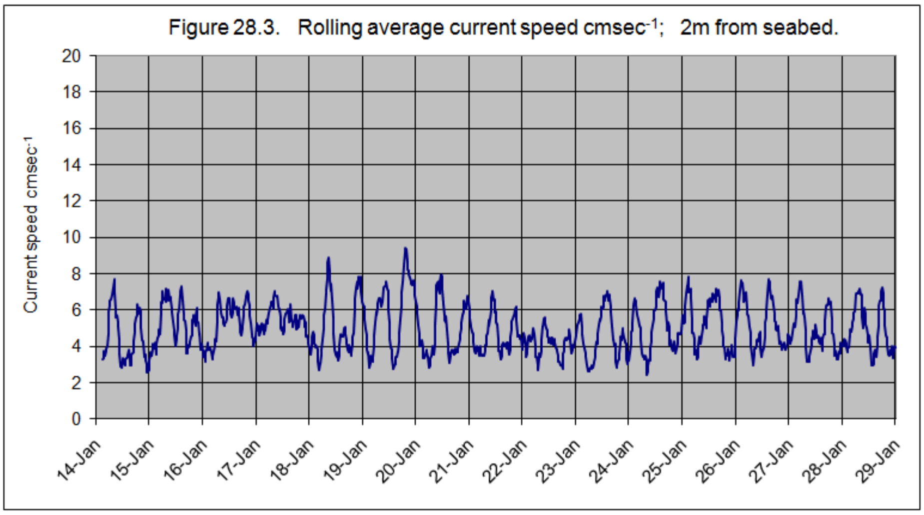


Figure 28.3. Rolling average current speed cmsec^{-1}; 2m from seabed.

Figures 29.1 to 29.3.
Marine Harvest Ireland; Hydrography Report.
Shot Head Bantry Bay; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Vertical current speed (cmsec^{-1}) at 26.3m, 16.4m and 2.0m from the seabed.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.

Figure 29.1. Vertical current speed cmsec^{-1}, 26.3m from seabed.

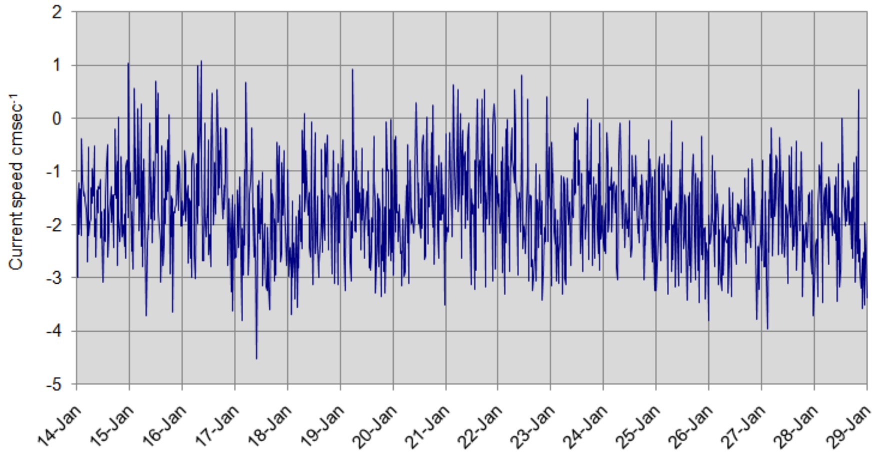


Figure 29.2. Vertical current speed cmsec^{-1}, 16.4m from seabed.

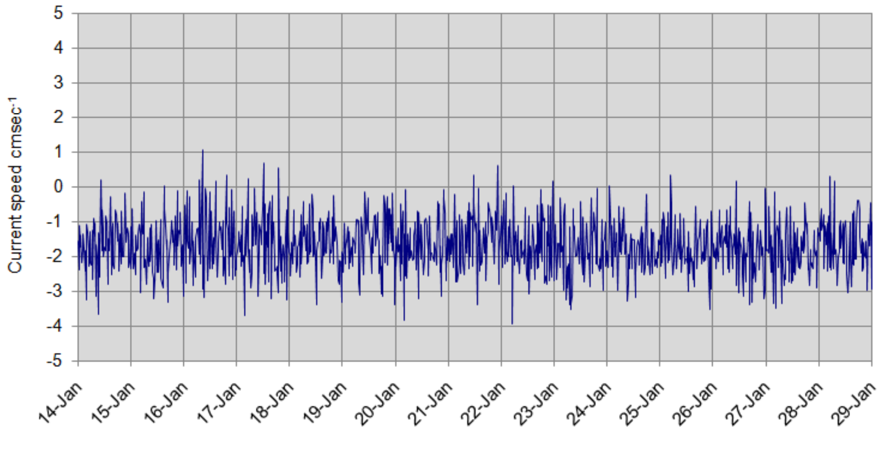


Figure 29.3. Vertical current speed cmsec^{-1}, 2m from seabed.

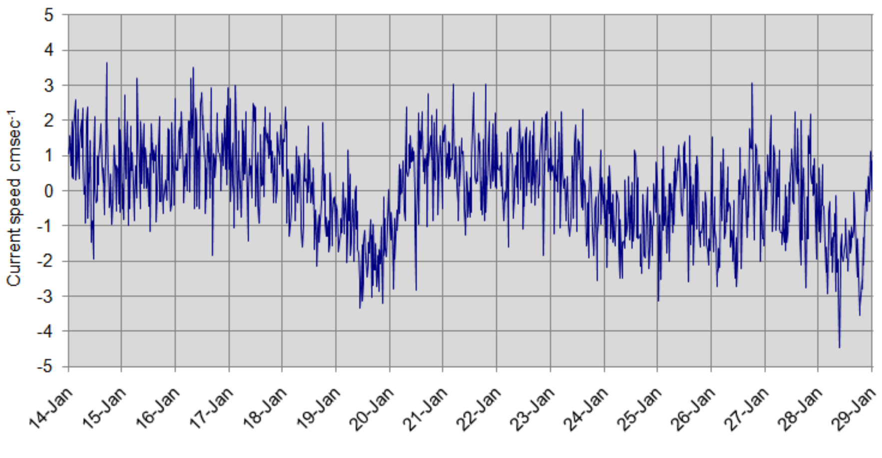


Figure 30.1 to 30.3.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Radar graphs of mean current speed (cmsec^{-1}) in 10° interval direction bins at 26.3m, 16.4m and 2.0m from the seabed.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.

Figure 30.1. Mean current speed by direction at 10° intervals; 26.3m from seabed.

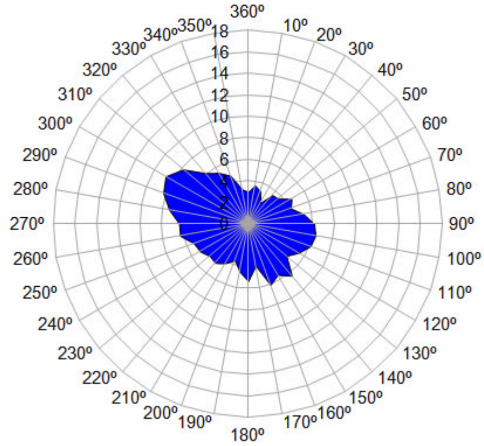


Figure 30.2. Mean current speed by direction at 10° intervals; 16.4m from seabed.

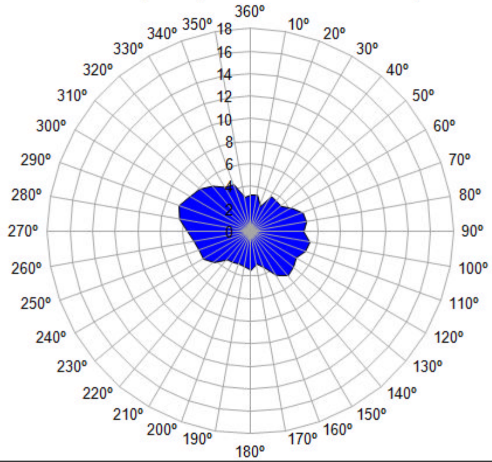


Figure 30.3. Mean current speed by direction at 10° intervals; 2.0m from seabed.

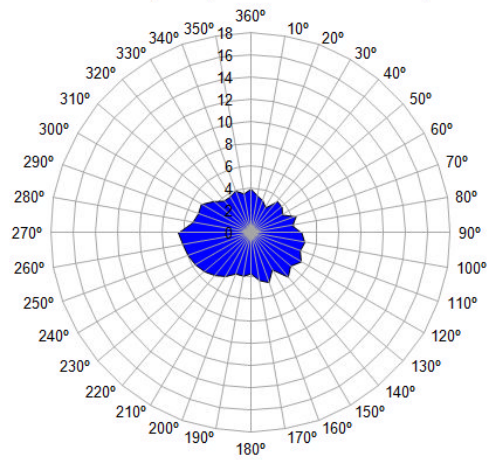


Table 3 and Figures 31 and 32 describe the frequency of occurrence of current speed at the three selected RDCP sensor depths.

Table 3.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
Percent frequency of current readings within speed bins over the period 00:00 14th January to 00:00 29th January 2010 (GMT).

Speed bins in $cmsec^{-1}$	Sensor depth (to seabed)		
	2m	16.4m	26.3m
< 3	25.35%	28.86%	22.85%
3 to 5	30.06%	30.80%	25.16%
5 to 7.5	27.10%	22.48%	24.98%
7.5 to 10	13.41%	12.12%	14.43%
10 to 12.5	3.33%	4.44%	6.94%
12.5 to 15	0.74%	0.93%	3.24%
> 15	0.00%	0.37%	2.41%
Total	100.00%	100.00%	100.00%

Currents at all three depths averaged close to or just over $5cmsec^{-1}$. Fastest mean current occurred at the shallowest sensor 26.3m from the seabed, at $5.88cmsce^{-1}$, which occurred for 56.6% of the recording period. Current speeds of greater than $5msec^{-1}$ occurred for 45-55% and at greater than $7.5cmsec^{-1}$ for 15-25% of the time, at all depths. Currents rarely exceeded $15cmsec^{-1}$, the maximum being 2.4% of the time, of the time at the shallowest depth.

Licensed maximum site biomass and frequency and extent of benthic monitoring are generally gauged on mean current speed, at the sea surface and near the seabed. In this case, currents were monitored some weeks after the winter equinoxial spring tides when tidal flux from flood to ebb is not at its greatest (which occurs during the spring and autumnal equinoxes) and this can be expected to be reflected in current speed. Equally, more or less still-weather conditions pertained throughout the monitoring period. On the basis that mean current speed was close to or exceeded $5cmsec^{-1}$ at this time of year at all depths monitored, it is submitted that the site is suitable for a maximum standing stock of over 1,000 tonnes and that level 2 monitoring should be applied[13] as a licence condition, should a licence be granted.

13 See Table 1, DAFF Monitoring Protocol Number 1 for Offshore Finfish farms; benthic monitoring, revised December 2008.

Figure 31.1 to 31.3.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Percent frequency distribution of current speed, ($cmsec^{-1}$), at 26.3m, 16.4m and 2.0m from the seabed.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.

Figure 31.1. Current speed % frequency distribution; 26.3m from seabed.

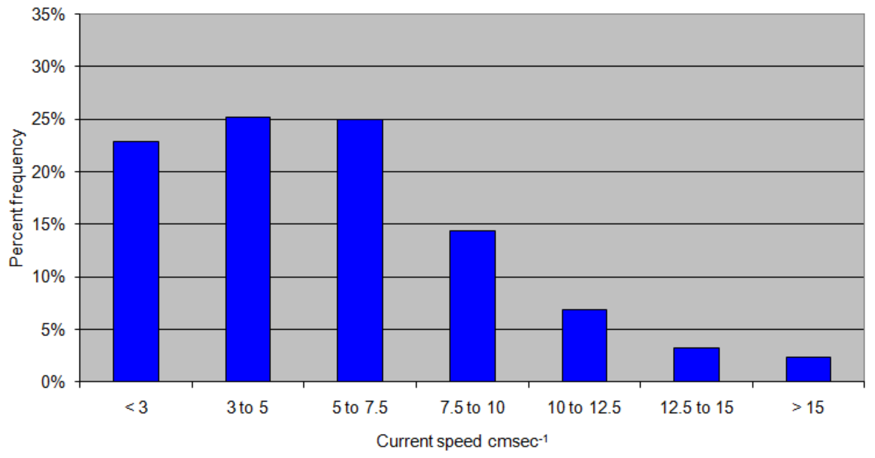


Figure 31.2. Current speed % frequency distribution; 16.4m from seabed.

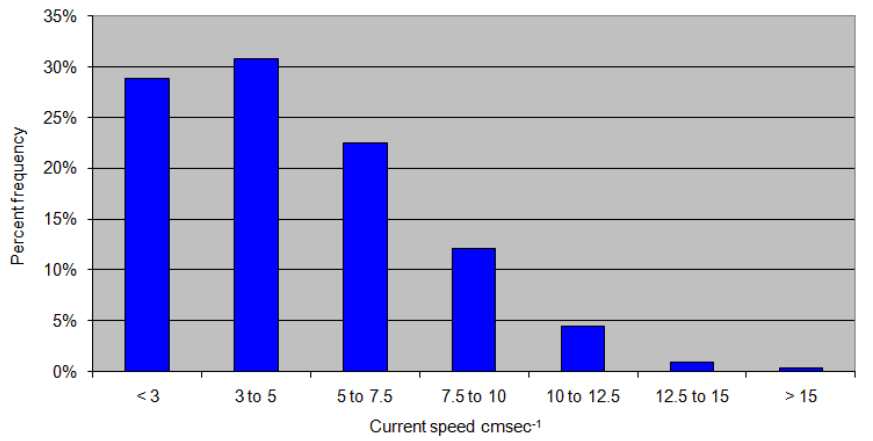
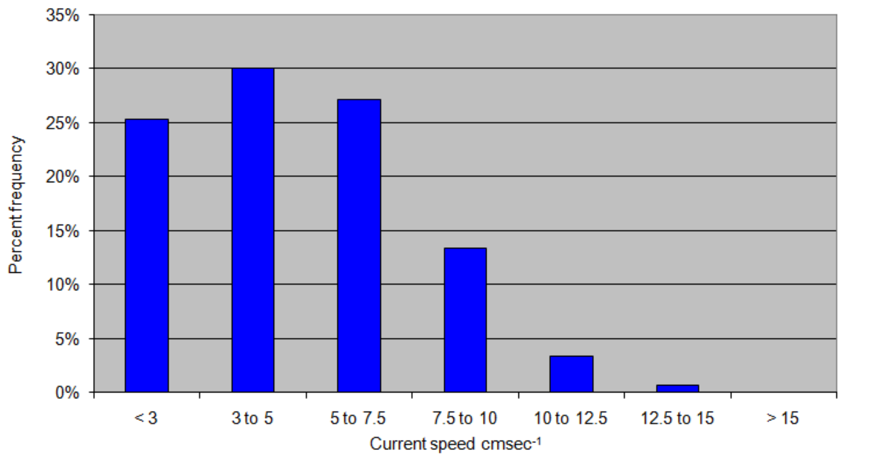


Figure 31.3. Current speed % frequency distribution; 2m from seabed.



Figures 32.1 to 32.3.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Current speed vs. percentile at 26.3m, 16.4m and 2.0m from the seabed.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.

Figure 32.1. Current speed against percentile at 26.3m from seabed.

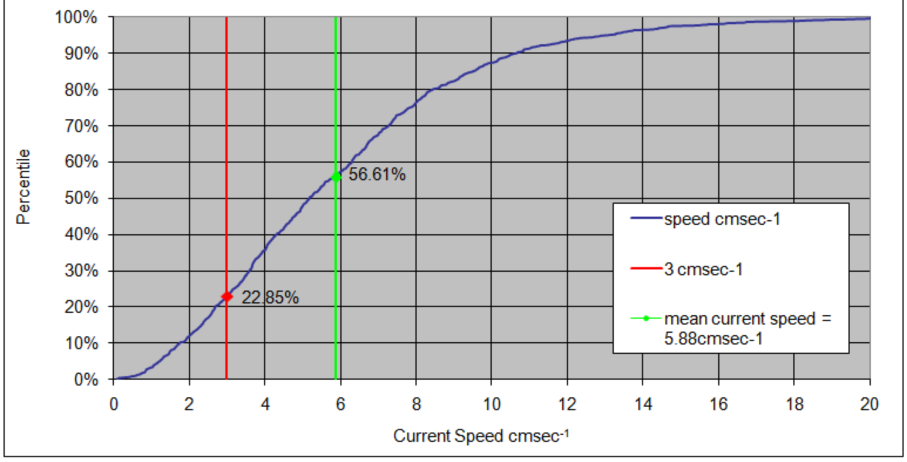


Figure 32.2. Current speed against percentile at 16.4m from seabed.

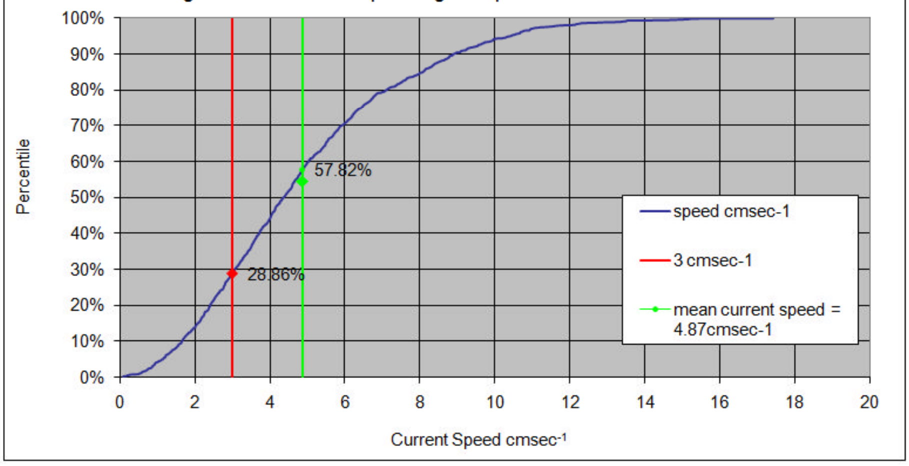
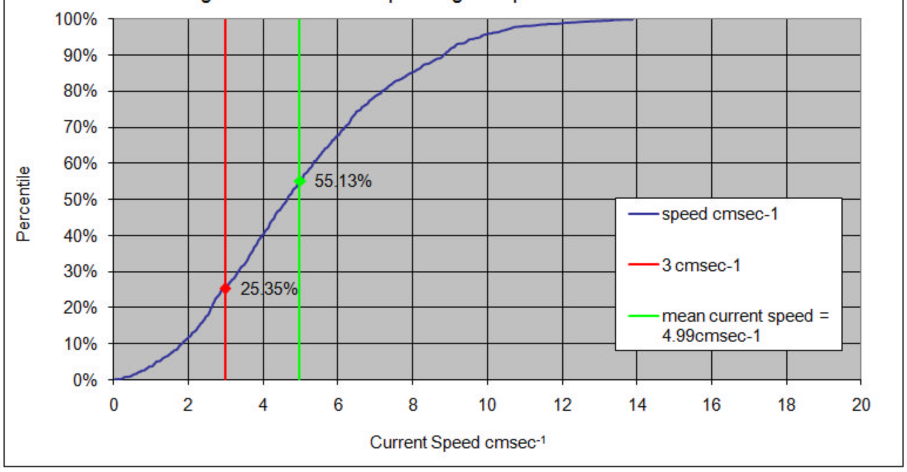


Figure 32.3. Current speed against percentile at 2m from seabed.



Although wind induction may be a factor in the current speeds and directions recorded, especially near the surface, wind does not seem to have been a material factor during the deployment period, as indicated by Figures 33 and 34. Winds rose above 6msec^{-1} only intermittently for short periods and rarely exceeded Beaufort Force 5 (10mcsec^{-1}). Winds must blow in a consistent direction at more than Beaufort Force 4 (5.5msec^{-1}) for some days before the effects of wind induction on currents become significant. Whilst this does happen in the site area, especially due to westerly winds during the winter months, it was not a factor during the deployment period which, by and large, shows a record of calm weather (that is tidally induced) currents only. It should nonetheless be noted again that that winds blow at over Beaufort Force 4 (5.5 msec^{-1}) for 50% of the time in the southwest of Ireland and that wind will therefore be a factor in augmenting current speeds above still weather levels for a significant proportion of the year (see Section 2.2).

2.4. Wave climate analysis.

2.4.1. Introduction

Wave climate analysis predicts likely sea conditions in an area. It is important to salmon farmers and regulators for the following reasons:-

- It indicates the mechanical and physical stresses to which farm structures and stocks will be subjected.
- It indicates the level of accessibility that a site will be afforded by meteorological conditions on a day-to-day basis.
- It has safety implications for site operations.

The engineering consultancy RPS[14] was commissioned carry out a wave climate analysis for the proposed Shot Head site area, using the Mike 21 computerised mathematical model developed at the Danish Hydraulics Institute (DHI). The analysis required the bathymetry around the south west coast of Ireland and Bantry Bay to be modelled accurately by setting up a grid system over the whole area and entering the depth value at each grid nodal point into the computer software. An assessment was made of the 1 in 50 year (that is with a 2% chance of occurring in any single year) and 1 in 1 year (that is the worst storm expected to occur annually) storm wave climate at the four corners and centre of the site. In addition the average summer and winter wave climates were predicted.

[14] RPS Group plc, Consulting Engineers, Elmwood House, Boucher Road, Belfast, County Antrim, BT12 6RZ. 0489 066 7914. www.rpsgroup.com. Report available from MHI, Rinmore, Letterkenny , County Donegal.

Figure 33.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Wind speed msec-1 and direction, recorded by recording anemometer.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.

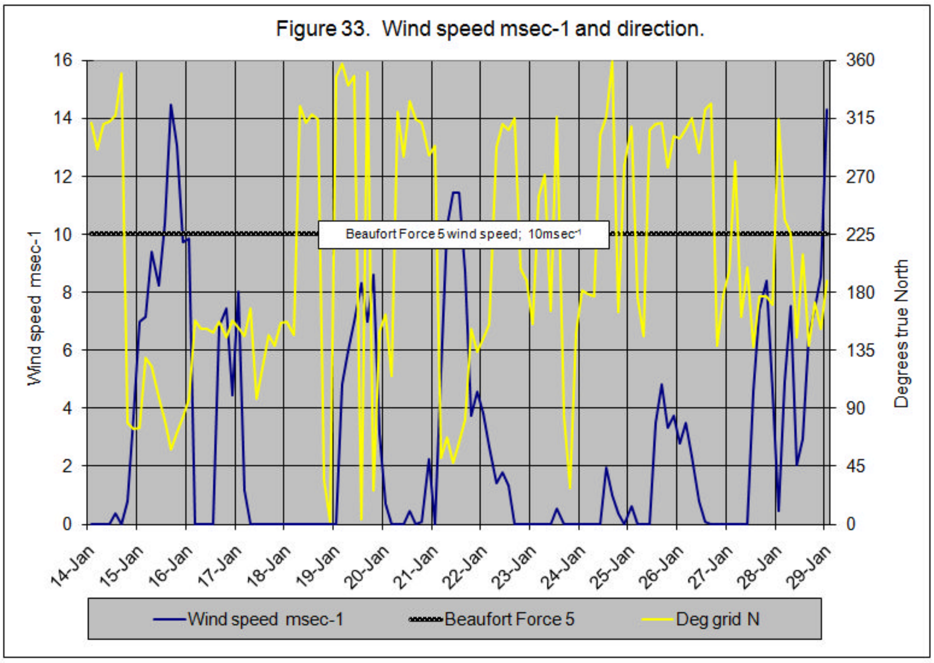
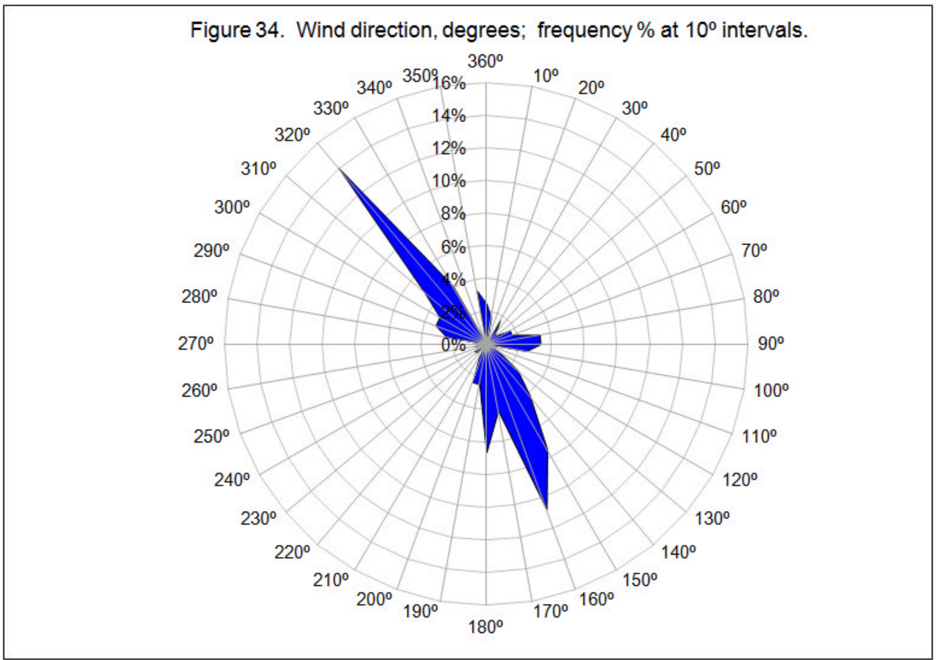


Figure 34.
EIS for a salmon farm site at Shot Head.
Hydrography survey; Deployment 2.
RDCP position ING Grid ref 085177.78E 047836.09N.
Radar graph of wind direction in degrees; frequency % at 10º intervals.
Period 00:00 14th January 2010 to 00:00 29th January 2010 (GMT); 15 days.



2.4.2. Wind and wave data.

RPS compared wind data prepared by Met Eireann for extreme wind speeds throughout the Ireland with results from wind recording stations on the south west coast. The results of the analysis showed that the Met Eireann data gave similar results for wave generation as the data from the wind recording stations. Therefore the Met Eireann extreme wind map wind data used by RPS in their study.

The length of the fetch over which the waves are generated determines the time period for which winds must blow to fully develop the waves. For the waves generated across the relatively short fetches within Bantry Bay, a 1 to 2 hour wind speed was found to be required for maximum wave generation, while a time scale of about 5 hours is required to fully develop the waves over the longer fetches from the south to west sector from the offshore wave data point in the Atlantic.

The over-water wind speed for 1 in 50 year North Atlantic storms from the SW to W direction was about 31$msec^{-1}$, while the value of the 1 in 50 year wind speed for wave generation over the fetches from the south east to south was calculated to be about 29$msec^{-1}$. For local fetches in Bantry Bay, from the east and south east, the over-water wind speed for 1 in 50 year storms was found to be 22 to 25$msec^{-1}$.

Storms of such intensity have a 63% chance of occurring once in 50 years, that is a 2% chance of occurring in any single year. While these extreme storms are not representative of the day-to-day environment at the site, they are the conditions for which the cage structure, moorings and so forth, should be specified.

For storms that have a 1 in 1 year return period, the wind speeds for wave generation over the North Atlantic reduced to about 22$msec^{-1}$ for south west to west storms. The value of the 1 in 1 year wind speed for wave generation over the fetches from the south to south east also reduced to 22$msec^{-1}$ while the over-water wind speed for 1 in 1 year storms from the east direction was found to be about 19$msec^{-1}$.

Offshore wind data is presented in the form of a wind rose in Figure 35. In the preparation of this wind rose, the raw data was classified into 15º sectors and in five wind speed ranges. The length of each segment in the figure represents the percentage frequency of time for winds blow from that 15º sector. It can be seen from the wind rose that, whilst the majority of strong offshore winds come from the south to west directions, they can also blow from north-westerly sectors.

Offshore wave data is presented in the form of a wind sea wave rose in Figure 36 and in the form of a swell wave rose in Figure 37. It can be seen from these figures that the largest wind sea waves originate from a west to WSW direction, whilst the largest swell waves arise, from a tighter, westerly sector. Detailed analysis of the offshore dataset set shows that, whilst high wind sea waves and swell waves normally coincide, there are occasions when the wave directions of the wind sea waves and swell waves can differ, depending on the nature of the particular depression approaching Ireland from the Atlantic.

A probabilistic analysis of the raw wind and wave data was also undertaken to estimate the wind speeds and wave heights that will occur in the site area during extreme storms. The raw data was reduced into 30º sectors and a statistical analysis undertaken using the best fit of five candidate distributions. An example of this statistical analysis, for the 240° dataset, that with the greatest penetration into Bantry Bay, as far as the Shot Head site, is shown in Figure 38.

RPS derived the wave data for storms from the south to WNW direction approaching the SW coast of Ireland from extreme value analysis of 12 years of 3-hourly data derived from the ECMWF European waters wave model. The 1 in 50 year storm from the south was found to have a significant wave height of 9.0m with a mean wave periods of 12.6seconds, while those from the south west have a significant wave height of 14.0m with a mean wave periods of 15.7seconds.

The largest waves were found to come from the westerly sector with significant wave heights of 16.0m and mean wave periods of 16.8seconds. The equivalent 1 in 1 year return period storm was found to have a significant wave height of 9.9m and a mean wave period of 13.2 seconds for westerly storms and 5.50m wave height with a mean period of 9.85 seconds for southerly storms.

The 12 years of data from the ECMWF European waters wave model was also used to assess the average summer and winter wave climates at the sites. The percentage of time that winds of Force 0-2, 3-4, 5-6, 7-8 and >8 were derived for each 30 degree sector for the summer months April to September and the winter months October to March. Similarly the offshore wind waves which matched these wind conditions for south to west directions were also extracted from the data set. In addition an analysis was made of the persistence of swell waves of heights 0.5-1m, 1-2m, 2-3m, 3-4m, 5m and 6m and greater for each month for direction sectors 210º, 240º and 270º.

Figure 35.
Enviromnental Impact Statement for Shot Head, Bantry Bay.
Wave Climate analysis.
Offshore wind rose; wind speeds over 10 knots (5.08msec-1).

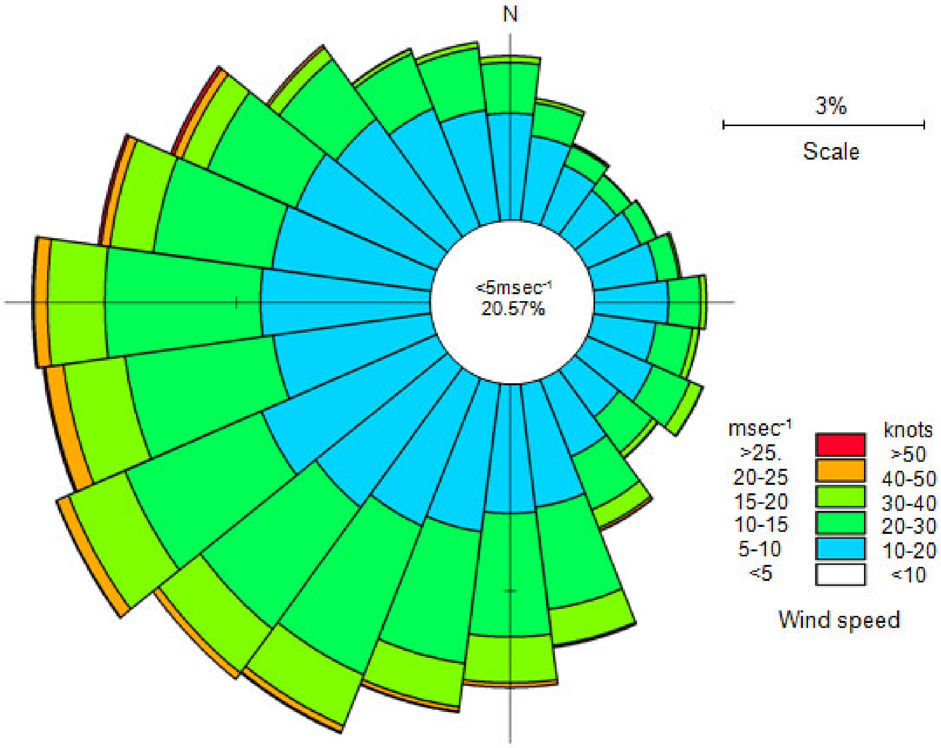


Figure 36.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Offshore wind sea wave rose; wave heights over 1.0m.

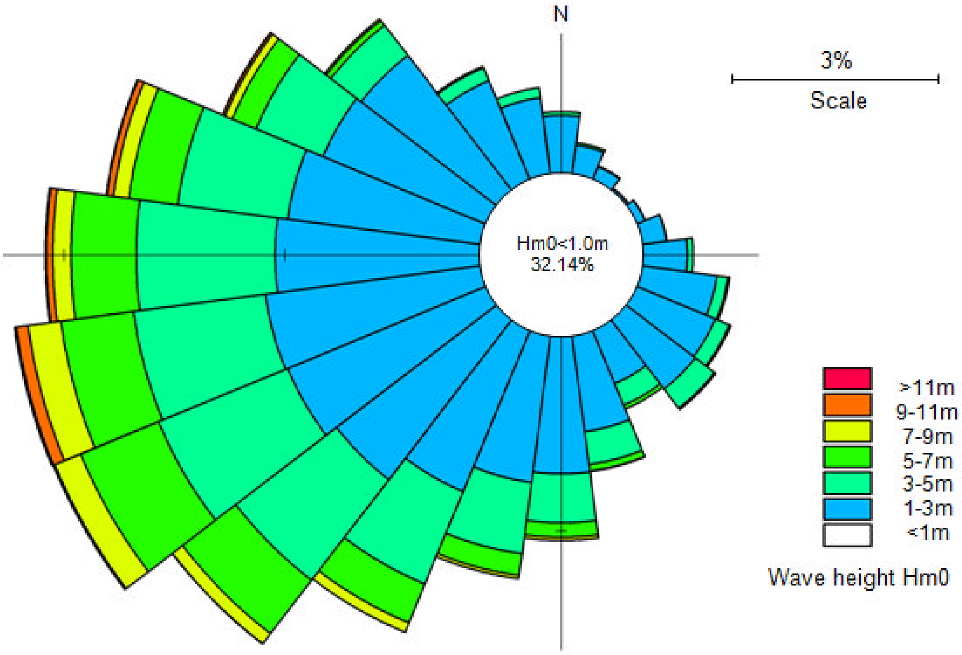


Figure 37.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Offshore swell wave rose – swell height > 1.0m

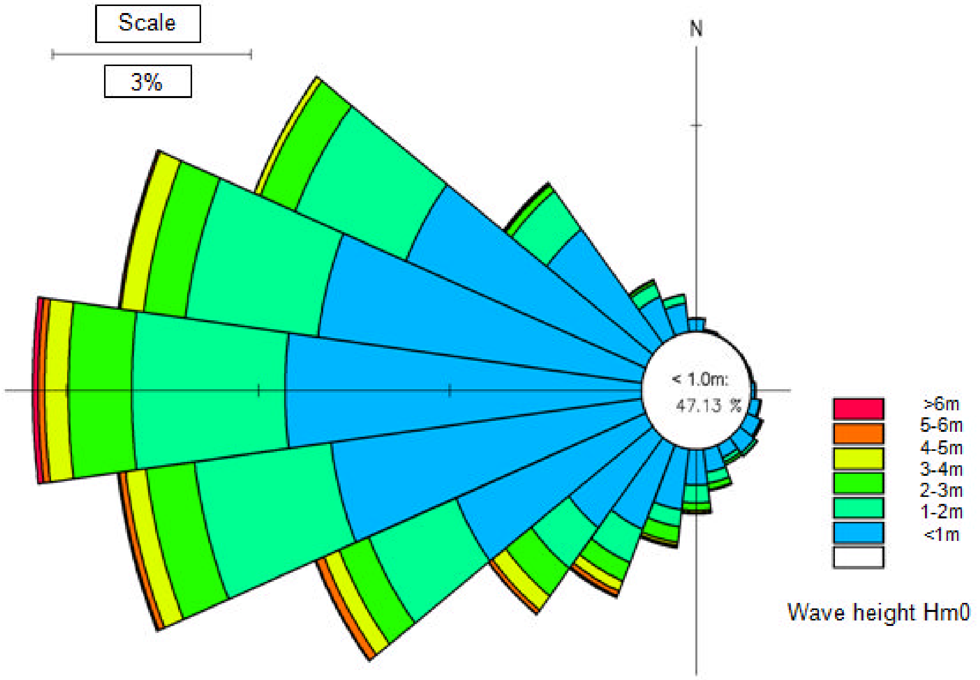
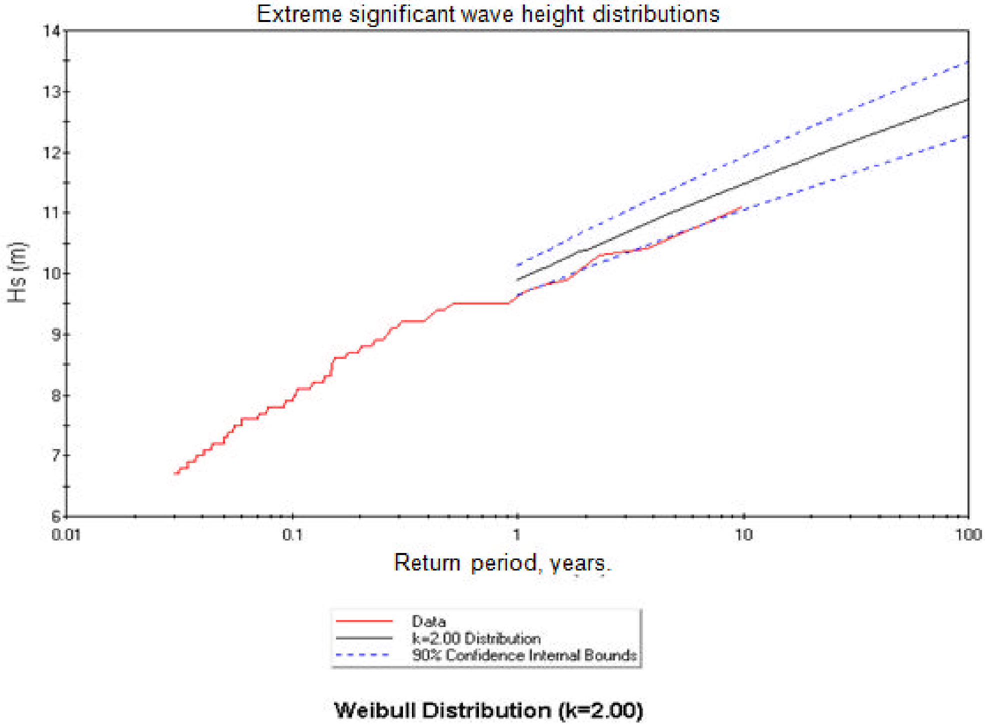


Figure 38.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Statistical analysis for offshore waves from 240°



2.4.3. Bathymetry and topography

The bathymetry and topography in the approaches to a site and in its immediate locality can have a considerable influence on both local wind and wave climate. Figure 35 to 37 show the wind rose, wind wave rose and the swell wave rose for the offshore area of the south west of Ireland. In the case of Shot Head, the sheltering topography of the Sheep's Head and Beara Peninsulae, as well as shelter provided by Bear Island greatly limits the sector from which offshore winds, wind waves and swell waves can approach the proposed site area. As a result, the effects of offshore winds and waves may be reduced, for example from due north and due south. However, Bantry Bay faces into the prevailing direction, from which the most frequent and powerful offshore winds and waves derive. In addition the height, power and direction of waves can be modified by shoaling, refraction, diffraction and frictional losses. The best means of predicting such outcomes is to model the combined effects of tide, wind, topography, bathymetry and offshore storm approach. RPS achieved this using DHI's MIKE 21 Nearshore Spectral Wave (NSW) software.

The analysis required the bathymetry around the south west coast of Ireland and Bantry Bay to be included in the models. This was undertaken using two grid systems, one set up over the entire region and the other over Bantry Bay and Dunmanus Bay. The depth value at each nodal point in both areas was entered in to the computer model.

Three separate model bathymetries were used to cover the area of the south west coast shown in Figure 39 while five model bathymetries were used for the simulations within Bantry Bay shown in Figure 40. The models of the south west coast had a grid resolution of 25m x 100m while those for the Bantry Bay had a resolution of 15m x 60m.

The x-axis of the models of the south west coast were aligned to the 180º, 225º and 270º directions. The models of the bays had the x-axis aligned to the 45º, 90º 135º, 180º, and 240º directions.

The bathymetry data for the models was obtained from digital charts for the area supplied by C-Map of Norway. All points were converted to the same datum, chosen as LAT, before being entered to the computer.

Figure 39.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Bathymetry of Bantry Bay; Bear Island to Widdy Island.

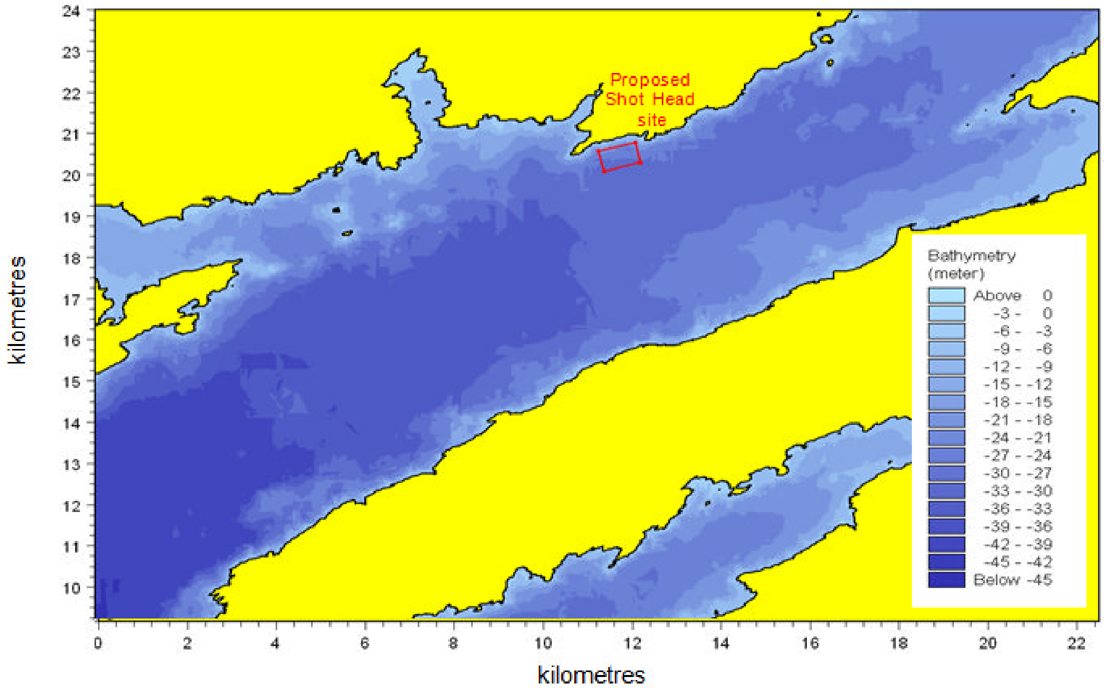
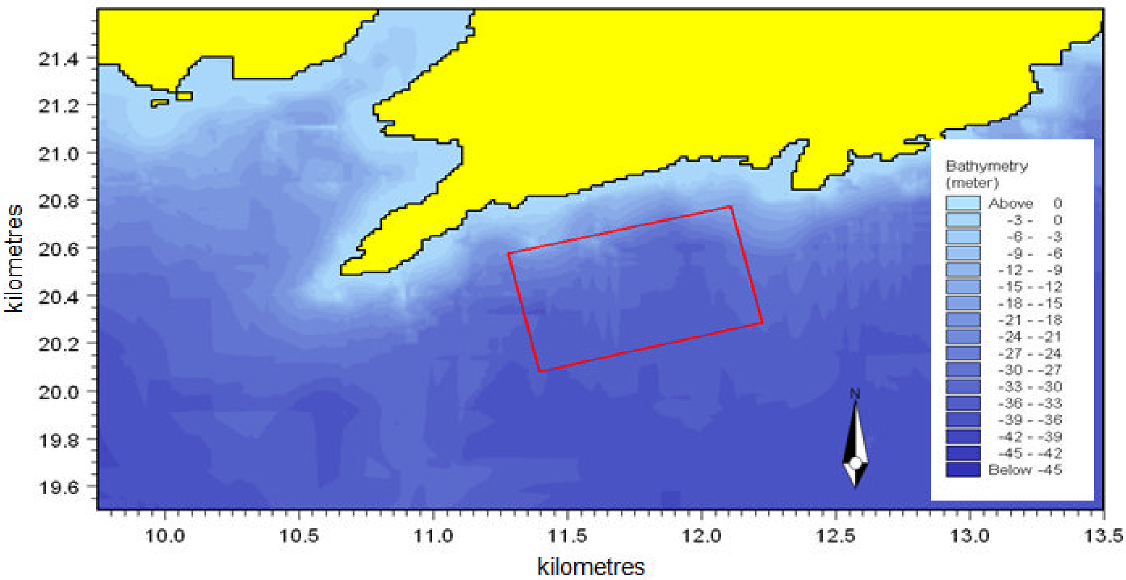


Figure 40.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Bathymetry of Shot Head site area.



2.4.4. Wave Models.

The wave study was undertaken using the MIKE NSW 21 model. MIKE NSW is a stationary, directionally decoupled parametric wind-wave model that describes the propagation, growth and decay of short-period and short-crested waves in near-shore areas. The model takes into account the effects of refraction, seabed friction and wave breaking.

The basic equations in the model are derived from the conservation equation for the spectral wave action density. A parameterisation of the conservation equation in the frequency domain is performed by introducing the zeroth and the first movement of the energy spectrum as dependent variables. The equations are solved using an Eulerian finite difference technique. The zeroth and the first moment of the action spectrum are calculated on a rectangular grid for a number of discrete directions. A once-through marching procedure is applied in the predominant direction of wave propagation.

The outputs from the model are integral wave parameters such as the significant wave height, the mean wave period, the mean wave direction, the directional standard deviation and radiation stresses.

2.4.5. Modelling Procedure.

The wave climate at the proposed Shot Head site was calculated using the latest wave spectral analysis techniques in conjunction with a two stage computational model simulation. Wave penetration by North Atlantic storms into Bantry Bay as well as wave generation across the bay itself was included in the analysis. The wave simulations were undertaken at a high water spring tide level plus the appropriate storm surge for storm directions from 180° to 300° and at mean high water spring for the remaining directions of 60° to 150° as these tidal levels allowed the greatest wave penetration into the sites.

The 25 x 100m resolution NSW grid models were used to simulate the Atlantic storm waves approaching the entrance to Bantry Bay for directions between 180° and 300°. The detailed modelling of the wave climate approaching the site from the south to west sector was then undertaken using a 15 x 60m grid NSW model of Bantry Bay with its x-axis aligned to 240º. The wave data at the boundary of the 15 x 60m grid model was taken from the results of the coarser grid model of the south west coast area.

The Atlantic storm wave characteristics at the model boundary for 1 in 50 year return period storms from the S to the WNW directions were calculated to have a significant wave heights varying between 9.00m to 16.0m with mean wave periods varying between of 12.6 to 16.8 seconds. The equivalent wave data for a 1 in 1 year return period storm indicated that waves with a significant wave height between 5.5m and 9.9m with mean wave periods between 9.85 and 13.2 seconds would be present at the model boundary. These storm waves were transformed to the area at the entrance to Bantry and Dunmanus Bays using the NSW model which also included local wind-generation in the south west coastal area. The model wave analysis also included simulations of average summer and winter month climate at the sites. These simulations used the same model bathymetries as the storm wave simulations but all the simulations were run at a water level of mean sea level. Separate wind sea and swell wave simulations were used for the average wave climate analysis to enable the frequency of swell wave activity at the sites to be included in the analysis.

Figure 41 shows the significant wave height and mean wave directions of the waves in the approaches to Bantry Bay during a 1 in 50 year return period storm from 240º, including wave penetration from the Atlantic. Figure 42 shows a more detailed picture of the wave climate at Shot Head. A 240º storm approach from offshore gives the greatest penetration to Shot Head and, thus, the most powerful wave forces. It can however be seen that the bathymetry of the bay significantly alters the wave climate as the storm waves approach. In particular, there is a considerable loss of wave height in the 10km stretch of open water between Bear Island and Shot Head, from some 9m significant wave height, to about 4m in a 1 in 50 year return period storm, due primarily to frictional losses at the shoreline and the seabed. The total free angle of approach to the site is of the order of 60º, between roughly 210º and 270º. The relative intensity of storm conditions approaching the site from around the compass are illustrated in Table 4 and Figures 44 and 45, in terms of wave height, period and direction.

The modelling of the storm wave generated across the fetches within Bantry Bay itself was undertaken using the 15m x 60m NSW model. The longest local fetch is of the order of 6km, from due east. Figure 43 shows the significant wave height and mean wave directions of the waves in a 1 in 50 year local storm from this direction. In this case, increasing wave height with fetch length is clearly illustrated, with Shot Head experiencing wave heights of 1.2 to 1.3m in a 1 in 50 year return period storm from this direction.

Figure 41.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Significant wave height and mean wave direction; 1 in 50 year storm
approaching SW coastal area from 240º

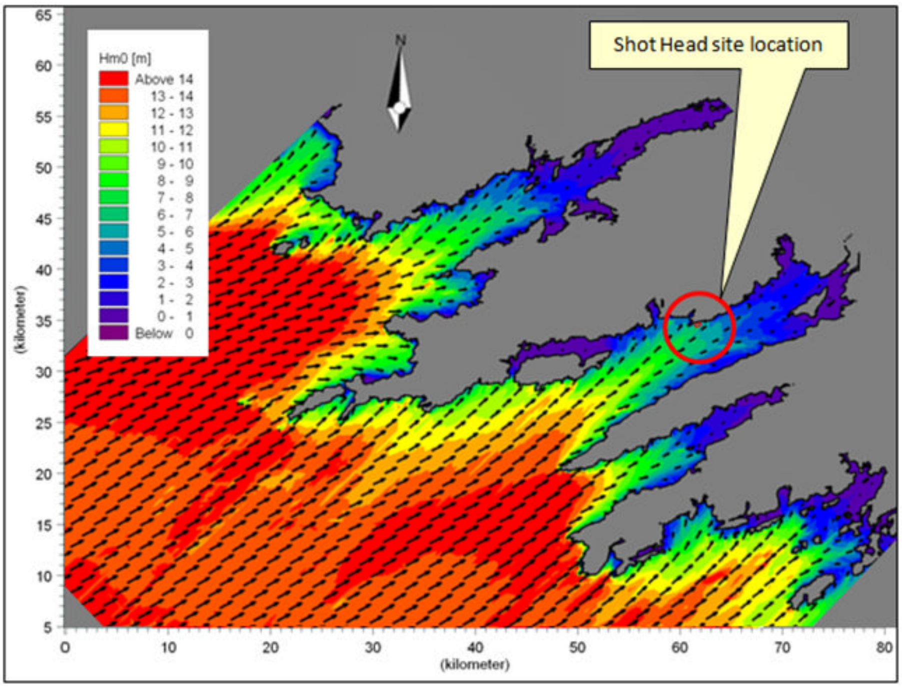


Figure 42.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Significant wave height and mean wave direction; 1 in 50 year storm
approaching the Shot Head site from 240° (i.e.to larger scale than Figure 39).
Note different wave height (Hm0) scale.

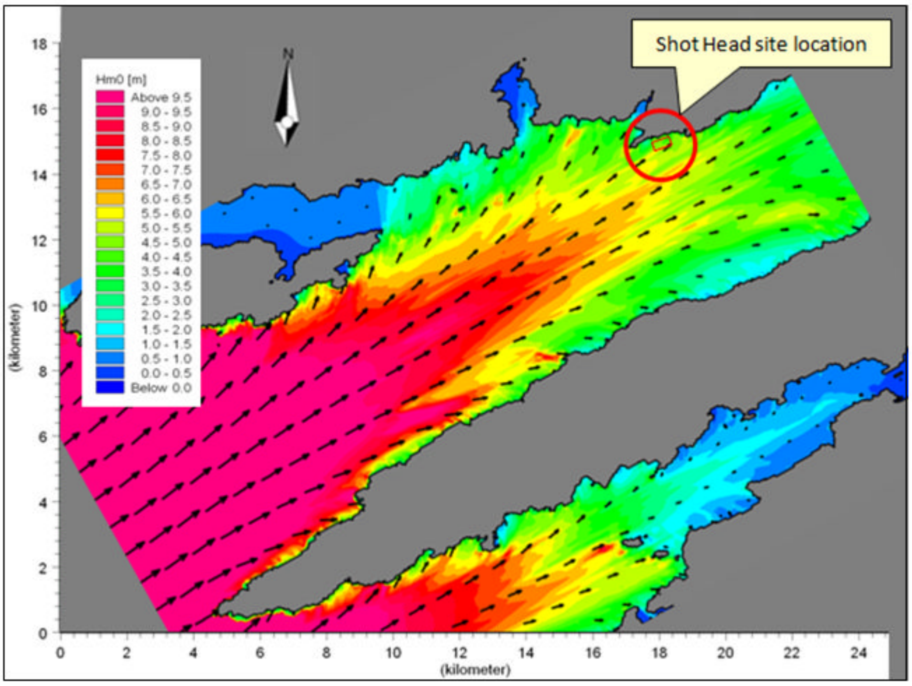
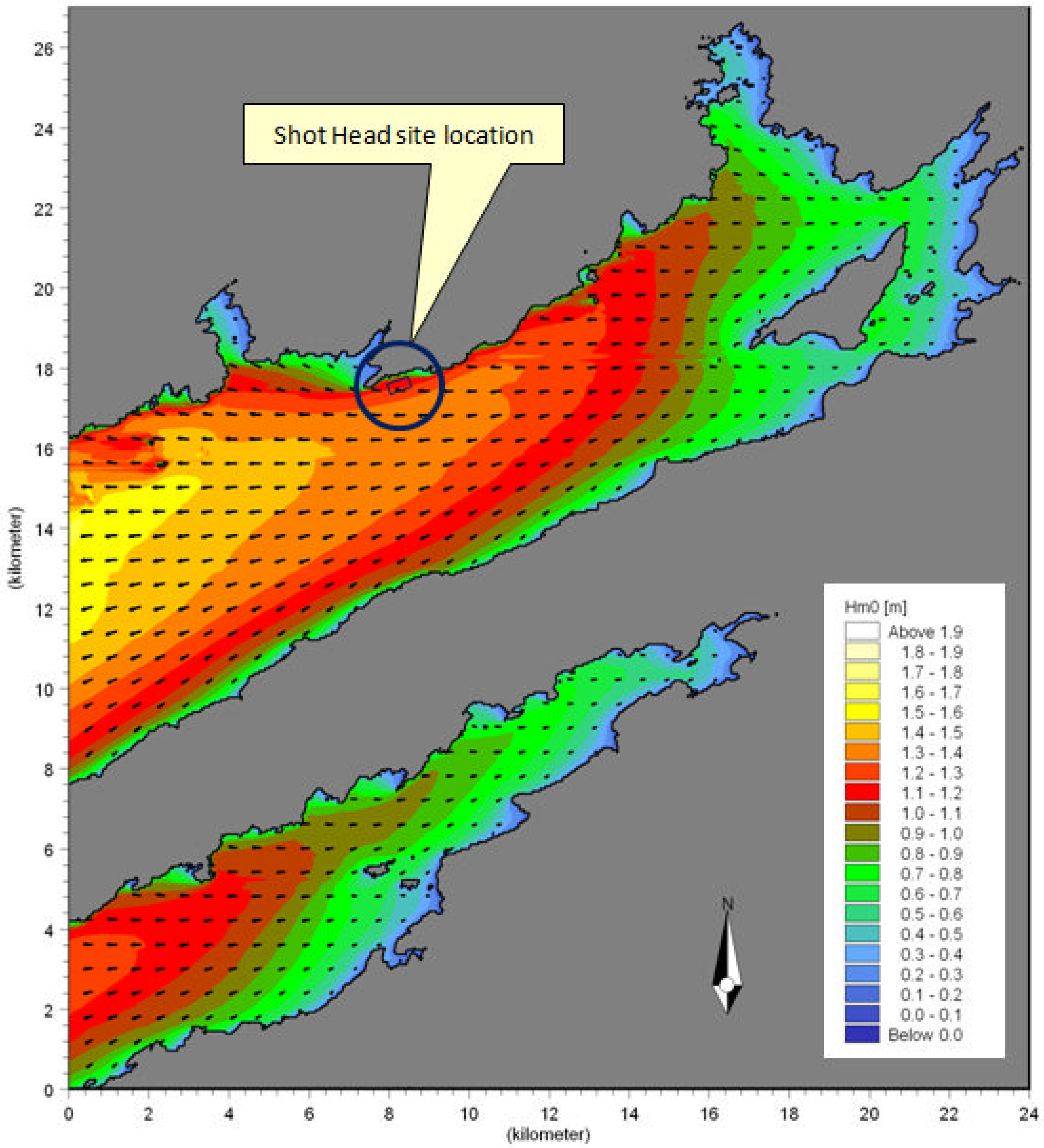


Figure 43.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Significant wave height and mean wave direction; 1 in 50 year storm approaching the Shot Head site from 90º (longest local fetch).



2.4.6. Wave characteristics at the Shot Head site.

Table 4 and Figures 44 to 45 investigate differences in wave climate between the centre and the four corners of the site area, by comparing significant wave heights and mean wave periods at 30º intervals, at each location, for 1 in 50 year and 1 in 1 year return period storms.

The figures clearly show that, at all locations and for both 1 in 50 year storms and 1 in 1 year storms, peak wave significant height is reached when the storm approaches from 240°. Significant wave height reduces by an average of 15-20% when the approach shifts from 240º, to 30º each side of it (210º and 270º), while mean wave period changes to a lesser degree within this range. However, beyond these points, both significant wave height and mean wave period reduce dramatically, to the point of being negligible (as predicted by the model), for wind directions between 300º and 60º, where the shelter offered by the landmasses of Inner Bantry Bay is the greatest and the across-water local fetches are the shortest.

For wind waves approaching across local fetches, from between 90º and 150º, both wave height and mean wave period remain very similar at around 1.1 to 1.5m and 2.9 to 3.2 seconds for both 1 in 50 year and 1 in 1 year storms.

Figure 42 to 44 also show that the northwest corner of the site offers more shelter than all other corners, for storms approaching from the south to the northwest (180º to 300º). The difference in wave height is greatest between the NW and SW corners, the latter showing a wave height of 60% to 70% greater than the former for storms approaching from between 180º and 300º . In fact, the 1 in 50 year wave climate for the northwest site corner is little different from the 1 in 1 year storm at all other corners in terms of significant wave height, although mean wave period remains relatively constant between the corners. The milder wave climate at the northwest corner is likely to be due in part to shelter provided by Shot Head but is probably more the result of the sheltering topography and bathymetry around Bear Island, which also offers protection to the northwest corner from Atlantic storms. It may be worth looking at locating the cages towards the northwest corner of the site, should the licence be granted.

Figures 44 to 47 also suggest that shelter from Bear Island may reduce wave height at all corners for 270º wind waves, whilst storms from 180º and 210º are reduced by the sheltering influence of the western end of the Sheep's Head Peninsula.

Table 4.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Shot Head storm wave climate for 1 in 50 and 1 in 1 year return period storms at site centre and site corners.
See Figures 42 and 43 for graphed data.

1 in 50 year return period storm				**1 in 1 year return period storm**			
Site centre							
Storm direction°	Hm0 m	Wave period sec	Mean wave direction°	Storm direction°	Hm0 m	Wave period sec	Mean wave direction°
60°	1.04	3.11	82	60°	0.68	2.71	82
90°	1.25	3.20	96	90°	0.82	2.78	95
120°	1.34	3.09	114	120°	0.88	2.68	113
150°	1.43	3.03	144	150°	0.94	2.63	144
180°	2.06	6.96	214	180°	1.29	5.13	212
210°	3.93	13.19	224	210°	2.54	10.60	225
240°	4.86	15.82	224	240°	3.30	12.84	225
270°	4.14	16.33	224	270°	2.48	12.78	225
300°	1.97	10.56	228	300°	1.10	7.43	233
SW site corner							
Storm direction°	Hm0 m	Wave period sec	Mean wave direction°	Storm direction°	Hm0 m	Wave period sec	Mean wave direction°
60°	1.15	3.18	78	60°	0.75	2.76	78
90°	1.31	3.24	92	90°	0.86	2.81	92
120°	1.37	3.11	110	120°	0.89	2.70	110
150°	1.41	3.00	144	150°	0.93	2.61	144
180°	2.22	7.77	218	180°	1.36	5.49	216
210°	4.44	13.70	227	210°	2.85	10.95	228
240°	5.55	15.92	227	240°	3.75	12.92	228
270°	4.74	16.39	227	270°	2.83	12.89	228
300°	2.30	10.12	233	300°	1.33	6.65	241
NW site corner							
Storm direction°	Hm0 m	Wave period sec	Mean wave direction°	Storm direction°	Hm0 m	Wave period sec	Mean wave direction°
60°	0.84	2.96	89	60°	0.56	2.58	89
90°	1.15	3.13	102	90°	0.76	2.72	102
120°	1.30	3.08	119	120°	0.85	2.66	119
150°	1.47	3.08	146	150°	0.97	2.68	145
180°	1.51	7.31	197	180°	1.01	5.01	197
210°	2.60	14.02	206	210°	1.64	11.17	208
240°	3.27	15.92	205	240°	2.14	12.93	207
270°	2.78	16.49	205	270°	1.60	12.74	207
300°	1.25	10.72	209	300°	0.64	7.20	216
NE site corner							
Storm direction°	Hm0 m	Wave period sec	Mean wave direction°	Storm direction°	Hm0 m	Wave period sec	Mean wave direction°
60°	0.68	2.83	93	60°	0.47	2.50	92
90°	1.08	3.14	105	90°	0.72	2.73	104
120°	1.19	2.99	124	120°	0.79	2.60	123
150°	1.40	3.02	148	150°	0.93	2.63	148
180°	1.92	7.72	206	180°	1.18	5.45	204
210°	3.74	13.64	214	210°	2.36	10.96	215
240°	4.70	15.85	214	240°	3.12	12.85	215
270°	4.02	16.32	213	270°	2.35	12.68	215
300°	1.84	10.60	217	300°	0.96	7.53	221
SE site corner							
Storm direction°	Hm0 m	Wave period sec	Mean wave direction°	Storm direction°	Hm0 m	Wave period sec	Mean wave direction°
60°	1.18	3.18	77	60°	0.77	2.76	76
90°	1.31	3.21	91	90°	0.86	2.79	91
120°	1.34	3.07	110	120°	0.88	2.66	110
150°	1.39	2.96	144	150°	0.91	2.57	144
180°	2.04	6.81	216	180°	1.26	4.97	214
210°	4.02	13.25	227	210°	2.61	10.60	228
240°	5.03	15.82	228	240°	3.43	12.83	229
270°	4.35	16.13	228	270°	2.64	12.69	229
300°	2.13	10.07	233	300°	1.23	6.99	239
1 in 50 year return period storm				**1 in 1 year return period storm**			

Figure 44.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Shot Head storm wave climate for 1 in 50 and 1 in 1 year storms.
Sheet 1; site centre and southwest and northwest site corners.

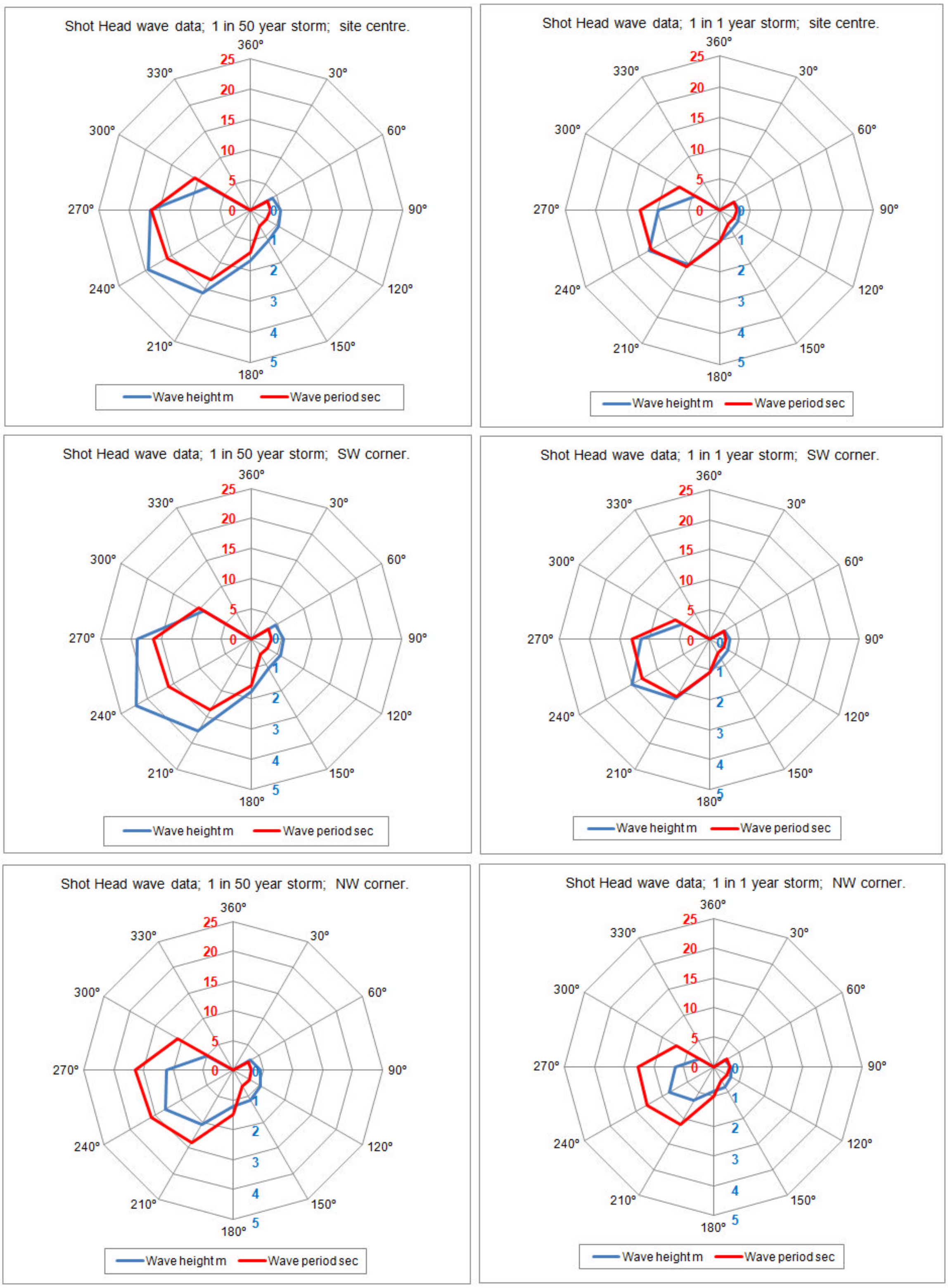
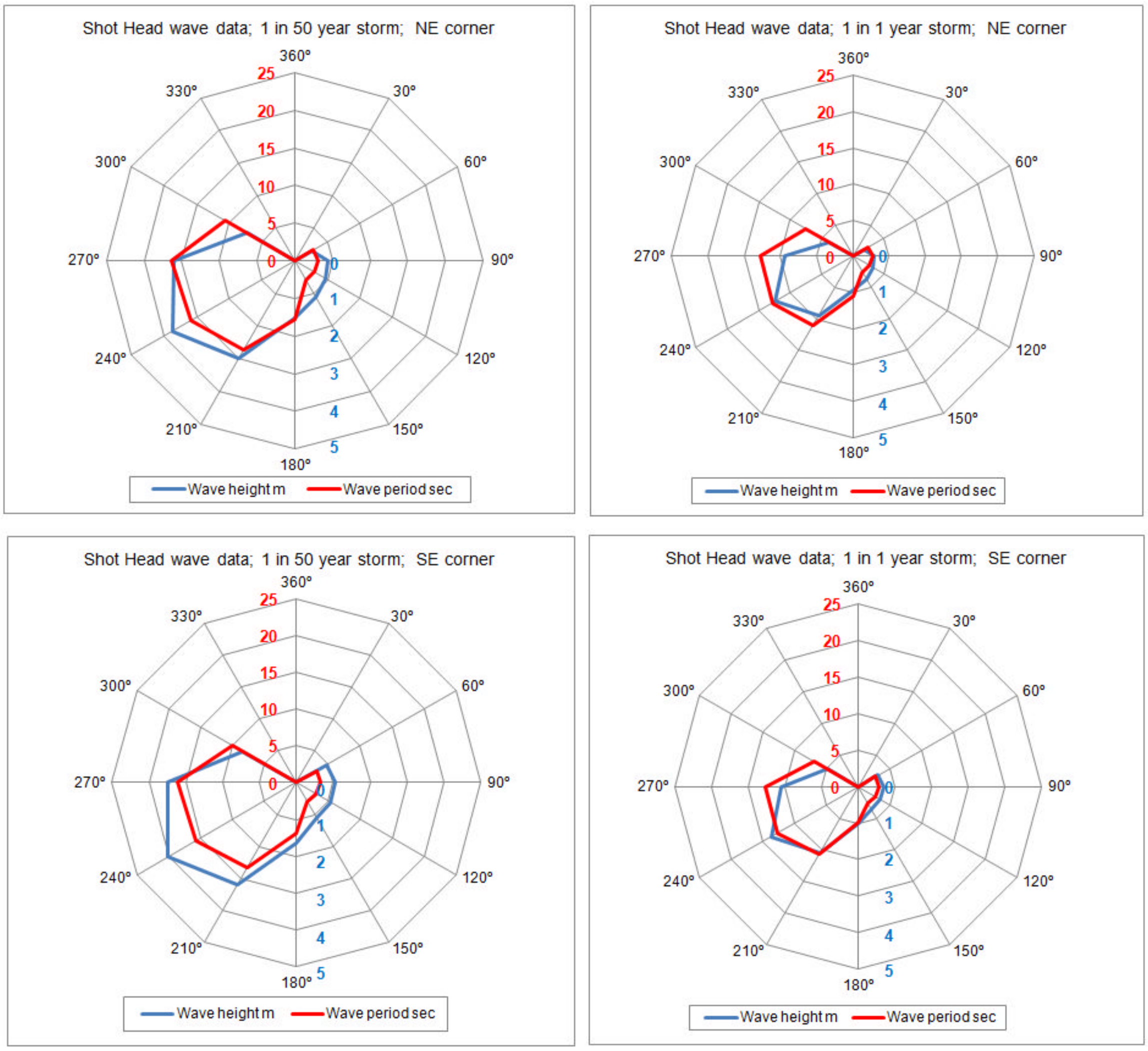


Figure 45.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Shot Head storm wave climate for 1 in 50 and 1 in 1 year storms.
Sheet 2; northeast and southeast site corners.



Depending upon the weather systems prevailing at any time, the wave climate expected at the Shot Head site results from two different types of wave spectra or a combination of the two, as follows:-

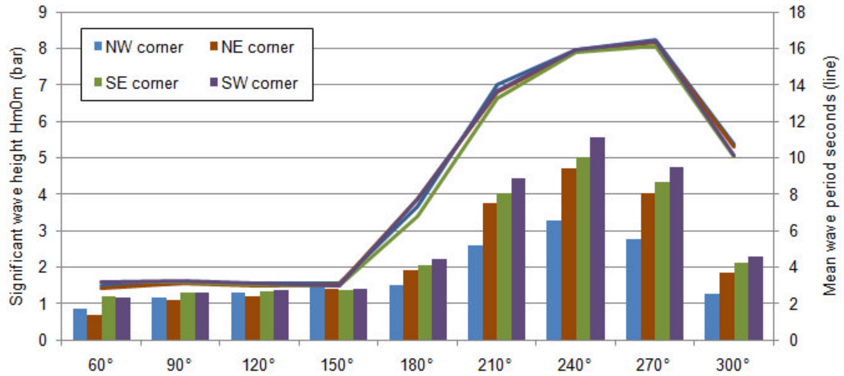
- Waves generated in the local fetch, from the east of the site area, which are of short wave length. The northwest corner of the site is not protected, relative to other site corners, in local storms as it is from Atlantic storms. At the site centre, typical wind wave significant height and wave period would be of the order of 0.7m to 1.0m and 2.6 to 2.8 seconds in a 1 in 1 year storm and 1 to 1.4m and 3.0 to 3.2 seconds respectively 1 in 50 year storm ; see Table 4 and Figure 44.

Figures 46 and 47.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Shot Head storm wave climate for 1 in 50 and 1 in 1 year storms.
Significant Wave Height m and Mean Wave Period secs at the four site corners.
See also Figures 44 and 45.

1 in 50 year return period storm

Storm direction°	NW corner		NE corner		SE corner		SW corner	
	Hm0 m	Wave period sec	Hm0 m	Wave period sec	Hm0 m	Wave period sec	Hm0 m	Wave period sec
60°	0.84	2.96	0.68	2.83	1.18	3.18	1.15	3.18
90°	1.15	3.13	1.08	3.14	1.31	3.21	1.31	3.24
120°	1.30	3.08	1.19	2.99	1.34	3.07	1.37	3.11
150°	1.47	3.08	1.40	3.02	1.39	2.96	1.41	3.00
180°	1.51	7.31	1.92	7.72	2.04	6.81	2.22	7.77
210°	2.60	14.02	3.74	13.64	4.02	13.25	4.44	13.70
240°	3.27	15.92	4.70	15.85	5.03	15.82	5.55	15.92
270°	2.78	16.49	4.02	16.32	4.35	16.13	4.74	16.39
300°	1.25	10.72	1.84	10.60	2.13	10.07	2.30	10.12

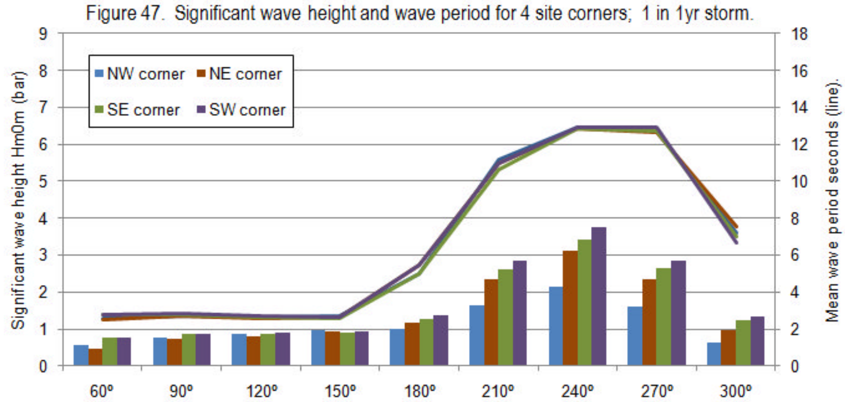
Figure 46. Significant wave height and wave period for 4 site corners; 1 in 50yr storm.



1 in 1 year return period storm

Storm direction°	NW corner		NE corner		SE corner		SW corner	
	Hm0 m	Wave period sec	Hm0 m	Wave period sec	Hm0 m	Wave period sec	Hm0 m	Wave period sec
60°	0.56	2.58	0.47	2.50	0.77	2.76	0.75	2.76
90°	0.76	2.72	0.72	2.73	0.86	2.79	0.86	2.81
120°	0.85	2.66	0.79	2.60	0.88	2.66	0.89	2.70
150°	0.97	2.68	0.93	2.63	0.91	2.57	0.93	2.61
180°	1.01	5.01	1.18	5.45	1.26	4.97	1.36	5.49
210°	1.64	11.17	2.36	10.96	2.61	10.6	2.85	10.95
240°	2.14	12.93	3.12	12.85	3.43	12.83	3.75	12.92
270°	1.60	12.74	2.35	12.68	2.64	12.69	2.83	12.89
300°	0.64	7.20	0.96	7.53	1.23	6.99	1.33	6.65

Figure 47. Significant wave height and wave period for 4 site corners; 1 in 1yr storm.



Whilst conditions would be choppy, such a wave climate would have little effect on the operation of a salmon farm site.

- Long swell type waves, originating across the very much longer Atlantic fetch, which result from storms generated in the North Atlantic. At the site centre, typical storm wave significant height and wave period would be of the order of 3.9m to 4.8m and 13 to 16 seconds respectively for a 1 in 50 year storm and 2.5m to 3.30m and 10.6 to 12.8 seconds for an average (annual) storm. Storm approach direction (wind) would be between 210º and 270º and mean wave direction at the site centre 224º to 225º in all cases ; see Table 4and Figure 44. Such large, swell type waves as seen in a 1 in 50 year storm would affect operations on salmon farm and may also affect access to the site.

- Combinations of short wavelength waves running across Bantry Bay (from the east) with swell waves running in from the Atlantic (from the west). Especially at longer storm return periods, this "combination wave climate" may produce difficult conditions which may temporarily affect staff accessibility and workability of the site and increase equipment stress just as much as, if not more than Atlantic storms alone, running from the west.

1 in 50 year return period local storms at Shot Head can be expected about 50% more intense than annual local storms, whilst 1-in-50-year return period storms from the Atlantic can be expected to be almost four times more intense than average annual storms. Storms of return periods between 1 year and 50 years can be expected to gain in intensity as return period increases but to be broadly similar in respect of wave return period and mean wave direction.

Table 5 reviews the projections generated for average summer (March to August) and winter (September to February) wave climates. The bold / highlighted figures in Table 5 show the % incidence of wind waves and swell waves of wave heights greater than 1m. In summer the height of the wind seas on the site will be less than 1 metre for 93% of the time with swells only exceeding 1 metre in height for about 6.25% of the time. As might be expected, average wave climate conditions are worse in the winter months; the height of the wind seas on the site will be less that 1 metre for 82% of the time with swells exceeding 1 metre in height for about 25.9% of the time.

Overall, the model predicts that the wave climate at Shot Head will be of medium to high intensity, increasing with increasing storm return period. That said, average site conditions are such that there would be few days in the year when access to the site or work on site would be unduly affected. This is primarily due to the dissipation of the force of Atlantic swell waves as they make their way up Bantry Bay, into the relatively shallower waters to the margins of the bay and, in the case of local storm wind waves, due to the relative shortness of local fetches.

Table 5.
EIS for a salmon farm site at Shot Head.
Wave Climate analysis.
Average summer and winter wave climate.

Percentage occurence in summer months.

Summer wind waves

Sector	<5.5 $msec^{-1}$	5.5 $msec^{-1}$ (Beaufort Force 4)				10.8 $msec^{-1}$ (Beaufort Force 6)				17.2 $msec^{-1}$ (Beaufort Force 8)				>17.2 $msec^{-1}$
	%	%	Hm0	Tm	MWD	%	Hm0	Tm	MWD	%	Hm0	Tm	MWD	%
60°	0.96	1.89	0.151	1.64	83	1.04	0.343	2.16	83	0.01	0.598	2.59	84	0.00
90°	0.83	2.19	0.185	1.7	97	1.01	0.423	2.23	97	0.06	0.747	2.7	97	0.00
120°	0.92	3.16	0.191	1.62	115	2.15	0.437	2.13	115	0.14	0.771	2.57	115	0.00
150°	0.79	3.55	0.179	1.51	145	2.65	0.41	1.99	145	0.31	0.726	2.41	145	0.00
180°	0.83	3.86	0.206	1.71	196	3.38	0.474	2.26	196	0.61	0.84	2.73	196	0.00
210°	0.75	4.31	0.350	3.01	229	4.38	0.909	4.98	229	**0.46**	**1.618**	**7.19**	**224**	0.01
240°	0.87	5.31	0.358	3.24	234	**5.31**	**1.012**	**5.61**	**234**	**0.46**	**1.849**	**8.04**	**226**	0.00
270°	0.9	5.37	0.285	2.96	239	5.2	0.708	4.97	236	**0.72**	**1.305**	**7.72**	**228**	0.00
300°	0.85	4.99	0.165	2.02	250	4.47	0.386	2.83	248	0.53	0.684	3.62	246	0.01

Summer swell waves

Sector	%	H swell	%	H swell	%	H swell	%	H swell	%	H swell	%	H swell
210°	0.35	0.189	5.84	0.394	3.02	0.702	**0.64**	**1.035**	**0.06**	**1.554**	**0**	**1.977**
240°	0.39	0.474	6.06	0.834	**4.26**	**1.167**	**1.1**	**1.487**	**0.14**	**1.929**	**0.01**	**2.186**
270°	0.32	0.052	6.02	0.135	4.11	0.318	1.4	0.54	0.34	0.92	**0.02**	**1.289**
Typical period sec	7.85sec		8.78sec		10.26sec		11.52sec		12.91sec		14.7sec	
Typical MWD°	228°		225°		222°		221°		220°		219°	

Percentage occurence in winter months.

Winter wind waves

Sector	<5.5 $msec^{-1}$	5.5 $msec^{-1}$ (Beaufort Force 4)				10.8 $msec^{-1}$ (Beaufort Force 6)				17.2 $msec^{-1}$ (Beaufort Force 8)				>17.2 $msec^{-1}$
	%	%	Hm0	Tm	MWD	%	Hm0	Tm	MWD	%	Hm0	Tm	MWD	%
60°	0.47	1.88	0.151	1.64	83	1.84	0.343	2.16	83	0.15	0.598	2.59	84	0.01
90°	0.46	1.9	0.185	1.7	97	1.93	0.423	2.23	97	0.35	0.747	2.7	97	0.01
120°	0.33	1.6	0.191	1.62	115	3.77	0.437	2.13	115	0.66	0.771	2.57	115	0.05
150°	0.43	2.13	0.179	1.51	145	3.19	0.41	1.99	145	0.82	0.726	2.41	145	0.08
180°	0.36	1.9	0.206	1.71	196	4.46	0.474	2.26	196	1.91	0.84	2.73	196	0.03
210°	0.37	2.84	0.350	3.01	229	6.54	0.909	4.98	229	**2.85**	**1.618**	**7.19**	**224**	0.14
240°	0.5	2.93	0.358	3.24	234	**7.33**	**1.012**	**5.61**	**234**	**3.03**	**1.849**	**8.04**	**226**	0.11
270°	0.57	2.72	0.285	2.96	239	6.45	0.708	4.97	236	**3.46**	**1.305**	**7.72**	**228**	0.21
300°	0.56	2.6	0.165	2.02	250	6.04	0.386	2.83	248	1.93	0.684	3.62	246	0.11

Winter swell waves

Sector	%	H swell	%	H swell	%	H swell	%	H swell	%	H swell	%	H swell
210°	0.01	0.189	1.97	0.394	4.88	0.702	**3.51**	**1.035**	**2.2**	**1.554**	**0.27**	**1.977**
240°	0.03	0.474	1.94	0.834	**4.17**	**1.167**	**3.66**	**1.487**	**3.62**	**1.929**	**0.46**	**2.186**
270°	0.01	0.052	1.59	0.135	3.82	0.318	3.73	0.54	3.7	0.92	**0.56**	**1.289**
Typical period sec	7.85sec		8.78sec		10.26sec		11.52sec		12.91sec		14.7sec	
Typical MWD°	228°		225°		222°		221°		220°		219°	

2.5. Water exchange

Water exchange can be simply defined by the calculation of the flushing time for a given water body[15]. Flushing time is estimated for Bantry Bay, in Table 5, on the basis of an estimated area from a line drawn between Sheep's Head and Dursey Island of 230km^2, a mean low water depth of 45m, a mean spring tidal range of 2.9m and a mean neap tidal range of 1.3.

Table 6.
EIS for a salmon farm site at Shot Head.
Tidal prism model; estimated flushing time.
Bantry Bay.
Notes
1. Mean low water depth (D) is estimated from Figures 18 and 37.
2. Mean spring and neap tide ranges (Rs, Rn) are estimated from Castletownberehaven tide data and from Hydrography Survey January 2010.

Parameter	Notation	Data	Units
Bantry Bay low water sea area	A	230,000,000	m^2
Bantry Bay mean low water depth	D	45.00	m
Thus Bantry Bay mean low water volume	V = A x D	10,350,000,000	m^3
Mean tidal range neap tide	Rn	1.30	m
Mean tidal range spring tide	Rs	2.90	m
Thus mean neap tidal volume	Pn = A x Rn	299,000,000	m^3
Thus mean spring tidal volume	Ps = A x Rs	667,000,000	m^3
Mean neap flushing time (tidal cycles)	Tn = (V + Pn) / Pn	35.62	tidal cycles
Thus mean neap flushing time (days)	Dn = Tn / 2	17.81	days
Mean spring flushing time (tidal cycles)	Ts = (V + Ps) / Ps	16.52	tidal cycles
Thus mean spring flushing time (days)	Ds = Ts / 2	8.26	days
Mean neap daily flushing rate	Fn = V / Dn	581,209,503	m^3 / day
Mean spring daily flushing rate	Fs = V / Ds	1,253,235,908	m^3 / day
Thus mean monthly water flux for Bantry Bay	W = ((Fn + Fs) / 2) x 30.4167	27,898,887,872	m^3/month

Table 6 estimates the average still-weather flushing time for Bantry Bay at 17.81 days during neap tides and 8.26 days during spring tides and that an average of 28 billion m^3 water flushes the bay every month. This flushing time compares quite closely with the still-weather flushing time for Kenmare Bay of 11 days during spring tides and 21 days during neap tides reported by Irish Hydrodata in their report on the Current Circulation in Outer Kenmare Bay, in August 1990.

Such rates are typical for large open bays and inlets along Ireland's west coast, where a combination of relatively shallow low-water depths, large tidal amplitudes and lack of obstruction combine to promote rapid flushing. This contrasts, for example, with conditions found in some Scottish sea lochs and Norwegian Fjords and provides more sustainable conditions for the development of aquaculture than in either of those situations, where flushing

15 Edwards A., Sharples F. 1986. Scottish sea lochs; a catalogue. SMBA / NCC 110pp.

times can be slow, as the result of low tidal amplitudes and considerable depths, in some cases.
This simple means of estimating flushing time is justified on the basis that tidally driven flushing time is a conservative estimate of flushing in such areas, where wind-induced current is a significant factor in flushing. It is estimated that wind is a factor in tidal flushing at sustained wind speeds of over Beaufort Force 4, which blow for over 50% of the time in the Bantry Bay area. The impact of wind will be felt most between mid-September and mid-March, since it is during these months that the majority of windy days occur.

The net effect of the tidal flushing of Bantry Bay is the dilution, assimilation and dispersion of all anthropogenic and background inputs to the bay and their drift into the Atlantic circulation as a result of the westerly residual currents. Anthropogenic inputs include waste nutrients from livestock, fertilisers, forestry as well as human wastes, from open sewers, waste water treatment plants and septic tanks in the bay's catchment, plus wastes arising from aquaculture and other industries in the area. Background inputs include nutrients and other chemicals in solution in rainwater and atmospheric dust that make up natural precipitation, onto the terrestrial catchment and into the bay waters.

It has been demonstrated in dispersion and dilution studies in other Irish loughs and bays, that the effects of flushing far outweigh any likely impact from inputs. As a result, unsustainable accumulation or increase in concentration of soluble or suspended inputs does not occur. This is demonstrated by further flushing calculations, used in the estimation of nutrient flux and dispersal from the proposed salmon farm site area at Shot Head, in Section 4.7.

2.6. Physico-chemical features of the proposed site area.

The physico-chemical parameters most relevant to marine aquaculture and the local environment are seawater temperature, dissolved oxygen saturation (DO), salinity, clarity and silicate. Hensey Glan Uisce Teo and MHI have monitored physico-chemical and nutrient (see Section 2.7) parameters at many locations around the Irish coast, in particular in the vicinity of aquaculture installations, since the early nineteen nineties in many cases. Whilst this is probably the most extensive database of Irish inshore physico-chemical and nutrient conditions, this data, like many similar databases, offers only a “snapshot” in that samples are taken no more than once per month. Thus, in particular, extremes are unlikely to be detected.

Physico-chemical and nutrient conditions in the water column near fish farm sites in Bantry Bay have been monitored since 1991. The control site for

Figure 48.
Shot Head EIS.
Water column nutrient parameter monitoring.
Position of the Boatyard water column monitoring control site, relative to MHI farm sites (licensed and proposed).

Bantry Bay data, at the so called Boatyard site, has been monitored since March 2004, when it superseded an earlier location. Its position and coordinates are shown in Figure 48. The data collected, averaged by month, is given in Table 7. Average data are also shown graphically, by parameter, in Figure 49. The full, 19-year dataset for physico chemical and nutrient water parameters at the Bantry Bay control site is shown in Appendix 7. Water sampling and analysis for this purpose is carried out as required under the DAFF Monitoring Protocol Number 2[16]. This protocol requires that site data for operational sites is collected between December and March each year. Data was collected more frequently prior to the introduction of the protocol, as the data record indicates. There is currently no data for the Shot Head site itself. This will commence if and when the site is licensed and operational.

The data shows that, in general, trends in water physico-chemical features are seasonal and dictated by natural cycles. The following observations apply:-

2.6.1. Temperature.

The seawater temperature record, given in Table 7 and Figure 49.1, shows temperature at 0m (surface sample), 10m and 25m depths. As might be expected, annual temperature maxima occur seasonally between July and September and minima between January and March, with the greatest range in surface waters.

2.6.2. Dissolved oxygen saturation (DO).

Oxygen solubility varies inversely with temperature. Thus the seasonal variation in DO saturation in clean seawater shows a seasonal fluctuation, which runs counter to that for temperature. Within the seasonal ambient temperature range recorded over the nineteen year record of about 6°C to 18°C, the 100% DO saturation level of clean seawater of salinity 35‰ (see Table 7 and Figure 49.2), varies from 9.9ppm to 7.6ppm.

The DO data for the Boatyard control site collected by Hensey Glan Uisce since 1991 and, latterly by MHI, shows some readings outside this range. This can arise for a number of reasons, some of which are seasonal, in particular:-

- Salinity reduction, mainly of surface waters, due to the presence of freshwater (from high rainfall and run-off) and daylight oxygen production by primary production, due to heavy phytoplankton blooms. Both of this events can bring about temporary increase in DO saturation.

16 Monitoring Protocol No. 2 for Offshore Finfish Farms-Water Column Monitoring, August 2001.

Table 7

EIS for a salmon farm site at Shot Head.

Water column physico-chemical and nutrient parameter monitoring.

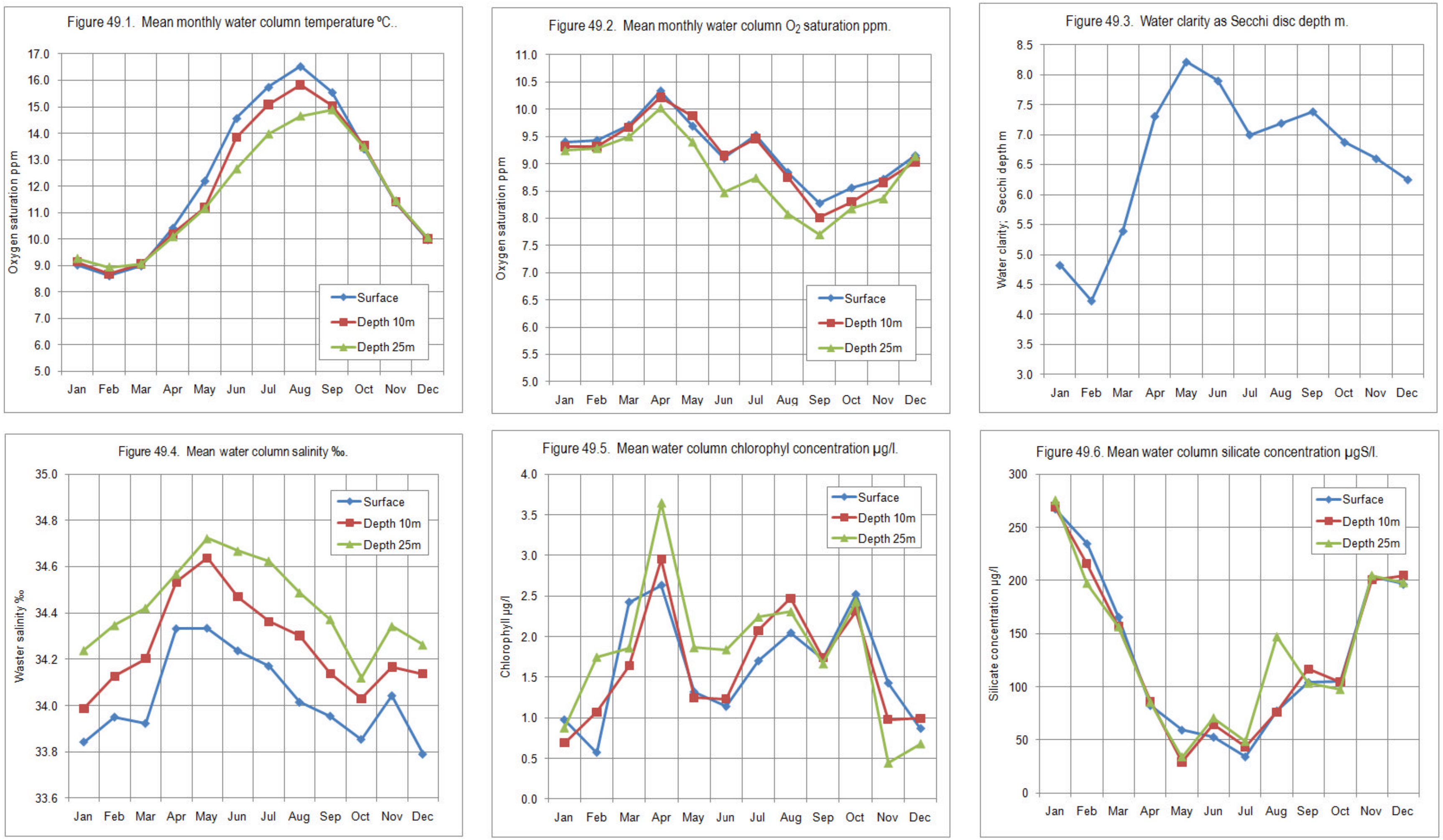
19-year mean database by month; Boatyard control station; 1991-2010.

Note. Samples collected monthly at three depths with automatic sampling bottle.

Physico-chemical parameters; see Figure 45.																		
Parameter	Temperature°C			Oxygen ppm			Secchi disc, depth			Salinity ‰			Chlorophyll µgm/l			Silicate µgmSi/l		
Depth	0m	10m	25m	0m	10m	25m		m		0m	10m	25m	0m	10m	25m	0m	10m	25m
Jan	9.02	9.13	9.25	9.40	9.32	9.24		4.82		33.84	33.99	34.24	0.97	0.69	0.88	267.37	269.53	275.24
Feb	8.61	8.67	8.93	9.43	9.32	9.29		4.23		33.95	34.13	34.35	0.57	1.07	1.75	234.73	215.83	197.21
Mar	8.99	9.05	9.05	9.71	9.67	9.50		5.39		33.92	34.20	34.42	2.42	1.64	1.86	165.76	156.89	156.18
Apr	10.42	10.20	10.07	10.34	10.22	10.03		7.31		34.33	34.53	34.57	2.63	2.95	3.65	82.69	86.43	85.12
May	12.20	11.19	11.15	9.69	9.88	9.40		8.21		34.33	34.64	34.72	1.32	1.25	1.86	59.55	29.21	33.88
Jun	14.57	13.85	12.64	9.09	9.15	8.47		7.90		34.24	34.47	34.67	1.14	1.23	1.84	52.92	64.49	70.56
Jul	15.75	15.09	13.96	9.52	9.46	8.75		7.00		34.17	34.36	34.63	1.70	2.08	2.24	34.44	43.75	48.44
Aug	16.53	15.83	14.64	8.84	8.75	8.08		7.19		34.01	34.30	34.49	2.04	2.47	2.31	77.65	76.16	146.91
Sep	15.55	15.04	14.88	8.27	8.01	7.70		7.38		33.95	34.14	34.37	1.72	1.74	1.67	104.35	116.67	103.32
Oct	13.41	13.54	13.47	8.56	8.30	8.18		6.88		33.85	34.03	34.12	2.52	2.31	2.43	105.00	104.72	97.25
Nov	11.38	11.40	11.44	8.72	8.66	8.36		6.60		34.04	34.17	34.34	1.43	0.98	0.44	203.39	200.52	204.47
Dec	9.98	10.00	10.05	9.15	9.03	9.14		6.25		33.79	34.14	34.26	0.87	0.99	0.68	196.56	204.75	197.68

Nutrient parameters; see Figure 46.																		
Parameter	Ammonia µgmN/l			Nitrite µgmN/l			Nitrate µgmN/l			Total N µgmN/l			Phosphate µgmP/l			Total P µgmP/l		
Position	0m	10m	25m	0m	10m	25m	0m	10m	25m	0m	10m	25m	0m	10m	25m	0m	10m	25m
Jan	13.40	13.98	15.14	3.05	2.72	2.83	132.16	125.11	131.20	210.63	206.65	198.27	21.24	22.03	21.74	26.33	28.38	31.24
Feb	12.11	19.23	11.95	3.36	3.59	2.97	113.98	114.87	117.69	189.46	188.28	177.06	21.58	18.91	19.22	34.79	25.51	24.42
Mar	18.21	15.58	18.39	3.56	3.83	4.35	77.24	84.08	92.90	170.27	181.35	186.09	16.10	17.34	19.38	21.88	22.78	25.53
Apr	10.85	13.74	12.15	2.35	2.87	3.22	33.32	53.95	65.75	143.92	152.60	157.08	14.88	17.57	19.12	19.22	18.19	24.90
May	18.07	16.26	18.65	0.42	0.79	0.98	2.71	6.49	12.46	61.32	63.56	57.87	3.72	3.10	3.51	8.89	5.48	7.65
Jun	16.66	17.37	20.61	0.42	0.79	2.29	1.40	3.22	27.11	86.52	88.48	118.58	3.10	4.55	7.34	8.06	11.68	15.40
Jul	14.15	16.25	20.42	0.88	0.77	0.91	1.73	1.59	2.52	150.73	111.49	113.12	6.12	5.43	7.05	16.04	10.39	11.39
Aug	20.08	19.60	26.18	0.51	0.89	3.36	2.15	2.43	22.12	108.03	82.27	118.63	4.55	5.37	11.78	11.88	12.61	16.84
Sep	25.52	20.56	20.93	1.77	1.87	1.77	19.46	19.83	23.85	149.47	147.98	128.24	10.64	11.26	12.50	15.71	16.33	16.12
Oct	29.81	27.75	23.90	7.23	7.28	8.35	29.26	38.13	33.74	132.53	114.15	117.93	11.99	9.92	11.99	17.15	16.33	18.39
Nov	15.77	23.13	23.04	7.56	6.35	6.01	67.59	76.14	89.96	145.80	151.25	154.67	16.04	16.12	17.15	21.66	22.51	22.67
Dec	25.28	21.47	21.20	2.85	3.04	2.57	99.79	93.29	95.98	167.65	178.43	169.51	19.38	19.30	20.15	41.33	26.67	29.88

Figure 49.
EIS for a salmon farm site at Shot Head.
Water column physico-chemical parameter monitoring; Boatyard control station.
19-year mean database by month, 1991-2010 for selected parameters.



Oxygen depletion due to phytoplankton respiration at night (when there is no photosynthetic oxygen production) or seasonal phytoplankton die-back, which can both occur in the event of heavy phytoplankton blooms, can both cause a temporary decrease in DO saturation.

Ambient DO within fish farm cages can be affected by many factors, in particular the respiratory activity of the stock, total stock biomass and stocking density and the rate of water exchange through the cages, itself related to water current, which may be influenced by such factors as wind, tide and the degree of net fouling. Fish respiratory rate bears a direct positive relationship with both fish biomass and ambient water temperature. In fully saturated water and, given a minimum DO requirement for healthy respiration of salmon of, say, 6ppm, available oxygen for respiration in full strength seawater will vary from about 3.9mg/l in winter to just 1.6mg/l in the warmest summer months (derived from 100% ambient DO minus the minimum respiratory requirement). Thus fish biomass, stocking density and water exchange during the summer months can be amongst the most critical factors affecting fish health and growth during the production cycle.

The production cycle envisaged for Shot Head has the advantage of commencing harvest (which reduces biomass from its peak) before the summer months (see Tables 15 and 16). In addition, under the organic standards, sufficient cage volume is provided to maintain mean stocking densities at less than $10kg/m^3$. This benefits general fish health and welfare and seabed conditions under the cages, since standing fish stock per unit seabed area is minimised. If a licence is granted for the proposed Shot Head site, and if full production is established, peak standing stock is expected to be reached during February to April in the second year, just prior to the onset of harvest.

2.6.3. Water clarity.

See Table 7 and Figure 49.3. Clarity in marine waters is affected by incident light levels, presence of humic and mineral suspended solids (arising from water disturbance, such as storms and freshwater run-off) and by plankton populations, as indicated by plankton counts or the ambient chlorophyll level. These occurrences show seasonal fluctuation. The Secchi disc, a 300mm black and white segmented disc, lowered to its point of disappearance, gives an approximate measure of clarity (or, rather, light absorption in the water column). In view of seasonal effects, it is wise to consider clarity along with other physico-chemical factors and indeed with the nutrient characteristics of the water; see Section 2.7.

Over the 19-year period of control site monitoring, clarity has remained within the normal seasonal range of 1.5 - 15m, which is regarded as normal for Irish inshore coastal waters.

2.6.4. Salinity.

The seawater salinity record, (see Table 7 and Figures 49.4) shows that salinity at the control site lies within the normal range for inshore coastal waters and is close to full-strength seawater (35‰) throughout the year. The occasional reduction in salinity, especially at the surface, is due to rainfall and freshwater run-off. It is noticeable that the main effect of freshening is during the winter months, when rainfall is the highest. The greatest effect is at the surface because freshwater is less dense than seawater. The freshening of seawater to the extent seen in Bantry Bay has no affect the marine salmon farm production.

2.6.5. Chlorophyll

Water column Chlorophyll indicates the level of phytoplankton primary production. It is also an indicator of phytoplankton blooms ("red tide"), when the numbers and types of organisms present may impact on fish and shellfish in aquaculture installations. The historical database for Chlorophyll at the Bantry Bay control site is shown in Table 7 and Figure 49.5. This indicates a seasonal increase in chlorophyll during the late spring to autumn period. This is indicative of the increase in phytoplankton levels in the water column, during the months with highest sunlight hours and warmer temperatures. This is a normal and natural phenomenon in inshore coastal waters, resulting from the uptake of inorganic nutrients and their incorporation into the growing phytoplankton biomass.

2.6.6. Silica.

Silicon is present in solution in seawater as silicic acid, although the term silicate is frequently used to describe it. Silicic acid is a nutrient, much as phosphorus and nitrogen (see Section 2.7). It is non-conservative and cycles seasonally between organically bound forms in plants and animals and inorganic forms in solution in precisely the same way as nitrogen and phosphorus do. This is why the graph for mean monthly silicate, shown in Figure 49.6, mirrors that for nitrate (Figure 50.3) and phosphate (Figure 50.5) so closely. Silicate is predominant in many seabed sediments in sand and as a constituent of the discarded shells of marine organisms, microorganisms (in particular marine dinoflagellates) and algae. Dissolution from seabed sediments is a ready source of silica, if it becomes depleted in solution in the water column. This is a source type which is not available for nitrates, phosphates or oxygen. Silica can also be present in the water column in mineral form, arising in humic matter which enters the sea from freshwater (especially during heavy rainfall). It can also enter the water column from the seabed by the resuspension of fine siliceous sands in rough weather. In this form it can have an impact on water clarity, as measured by Secchi disc (see Figure 49.3), which in part accounts for lower water clarity as measured by Secchi disc in winter months, when wind and wave climate are the harshest.

2.7. Water column nutrient chemistry.

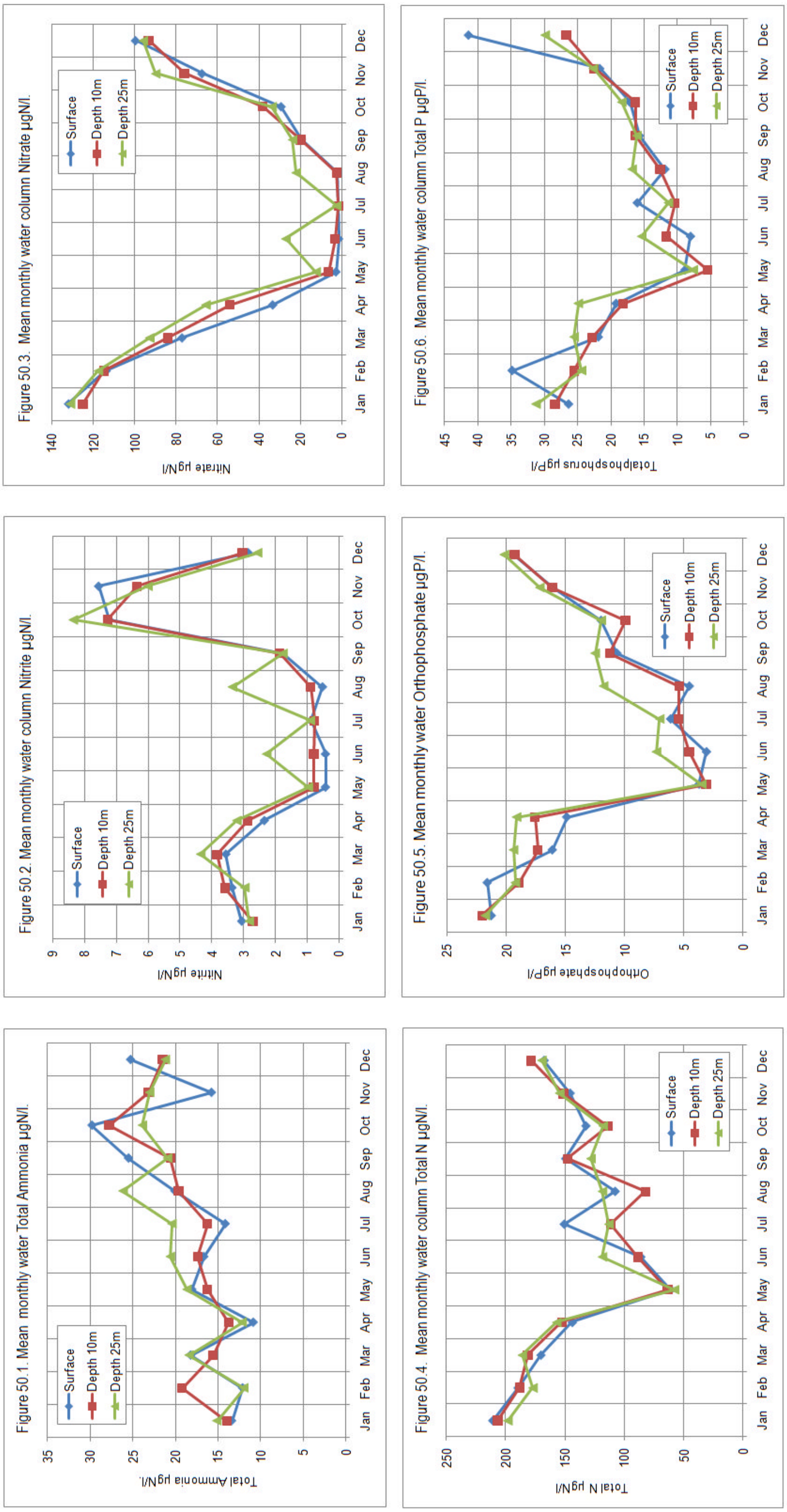
Monitored soluble nutrients comprise total ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and total nitrogen (measured as μgN/litre), orthophosphate phosphorus and total phosphorus (measured as μgP/ litre), silicate (measured as μgSi/litre) and chlorophyll (in μg / litre). Hensey Glan Uisce Teo and latterly MHI have monitored these parameters in Bantry Bay, along with physico-chemical parameters, since 1991.

2.7.1. Nitrogenous nutrients.

Ammonia is a natural constituent of seawater and the initial product of the remineralisation of organic nitrogen in biological matter as it breaks down in the late autumn and early winter months. The resulting inorganic nitrogen in solution is dispersed *vertically* through the water column by destratification (and, in some cases, by upwelling) and *horizontally* by tidal forces, to be rapidly grazed down by primary production and converted back into organic matter in the following season. This cycling of nitrogen between organic and inorganic states is part of the natural nitrogen cycle, as illustrated in the mean monthly data for nitrogen compounds in the water column, in Figure 50. The seasonal flux in ambient ammonia nitrogen concentration runs slightly ahead of that for nitrite, which itself runs ahead of that of nitrate nitrogen by about the same period, because ammonia is the first step in remineralisation, following which it undergoes bacterial oxidation to nitrite nitrogen and finally, to its most oxidised inorganic state, nitrate nitrogen. This natural process takes some weeks to complete.

Nitrogen is also the most important and first-limiting nutrient for organic growth (primary production) in marine systems. As a result, ammonia, nitrite and nitrate levels, as well as total nitrogen, all show strong seasonal trends in seawater; see Table 7 and Figures 50.1 to 50.4. Total nitrogen comprises all inorganic nitrogen sources in solution, plus organic sources, present in planktonic organisms in the water column.

Figure 50.
EIS for a salmon farm site at Shot Head.
Water column nutrient parameter monitoring; Boatyard control staiton.
19-year mean database by month, 1991-2010, for selected parameters.



From 1991 and 1996, prior to the establishment of a regulatory protocol, the water column at fish farms in Ireland was monitored monthly throughout the year, at both farm sites and control sites, for a range of physico-chemical and nutrient parameters. However, this practice was modified under the terms of the DAFF Protocol Number 2, for water column monitoring of offshore finfish farms. As a result, whilst physico-chemical parameters (temperature, oxygen, Secchi clarity, and salinity) continue to be monitored throughout the year (excluding December), chlorophyll is monitored only during its predicted peak months (April to October (when sunlight and temperature are highest), whilst nutrients are only monitored during their predicted peak months, between November and March (generally excluding December).

One consequence of this is that the mean monthly data given in Table 7 only includes data for non-peak years for nutrients and chlorophyll for the first five years or so of the 19-year data record. However, as far as is known, this is the only extensive database available for these parameters for Bantry Bay. Unlike the UK government, the Irish government has not monitored inshore waters around the coast as a matter of course. This has been left to individual organisations such as fish farms.

As well as being the first breakdown product of the remineralisation of organic nitrogen, ammonia is the main nitrogenous excretory product of fish. Above-ambient concentrations of ammonia near fish farms should be examined for indications of ammonia excretion or concentrations above sustainable levels. A concentration of 60μgN/l (= 4.2μg-AtN/l), is deemed to be the maximum safe level for the chronic exposure of salmonids, at pH 8.1 (normal pH of seawater) and 16°C (maximum mean temperature expected to apply at the Bantry Bay salmon farm sites). This is relative, say, to a mean ambient concentration at the Boatyard control site of under 30μgN/l, see Table 7 and Figure 50.1. Note that the projected peak biomass period, that at which ammonia excretion would be expected to peak at the proposed Shot Head site, is projected to occur around January biennially, that is the second January in each 24-month growth cycle. (see Figure 60). This is within the timeframe of the natural annual peak in dissolved inorganic nitrogen in the water column (see Figure 50.1 to 50.3). Because both discharged and natural dissolved inorganic nitrogen levels peak at about the same time, the data must be examined to make sure that the resultant elevation of ambient dissolved inorganic nitrogen (DIN) does not breach the established Environmental Quality Standard EQS for DIN. This is further examined in Section 4.

2.7.2. Phosphorus.

Control site seasonal ambient phosphate phosphorus and total phosphorus levels are given in Table 7 and Figure 50.5 and 50.6. These data mirror those for nitrate nitrogen, (Table 7 and Figure 50.3) due to the incorporation of phosphorus into organic matter in primary production and its subsequent remineralisation to inorganic phosphate phosphorus. Inorganic phosphorus is also a significant nutrient for algal growth. It is the primary limiting nutrient to primary production in freshwater systems, although secondary to inorganic nitrogen in marine systems. Since nitrogen and phosphorus are excreted by salmonids (from the digestion and metabolism of their feed), it is important both to estimate their production and to monitor them in waters containing fish farms. Projected discharge budgets for nitrogen and phosphorus for the proposed Shot Head site and other salmon farm sites in Bantry Bay, are calculated and discussed in Section 4.

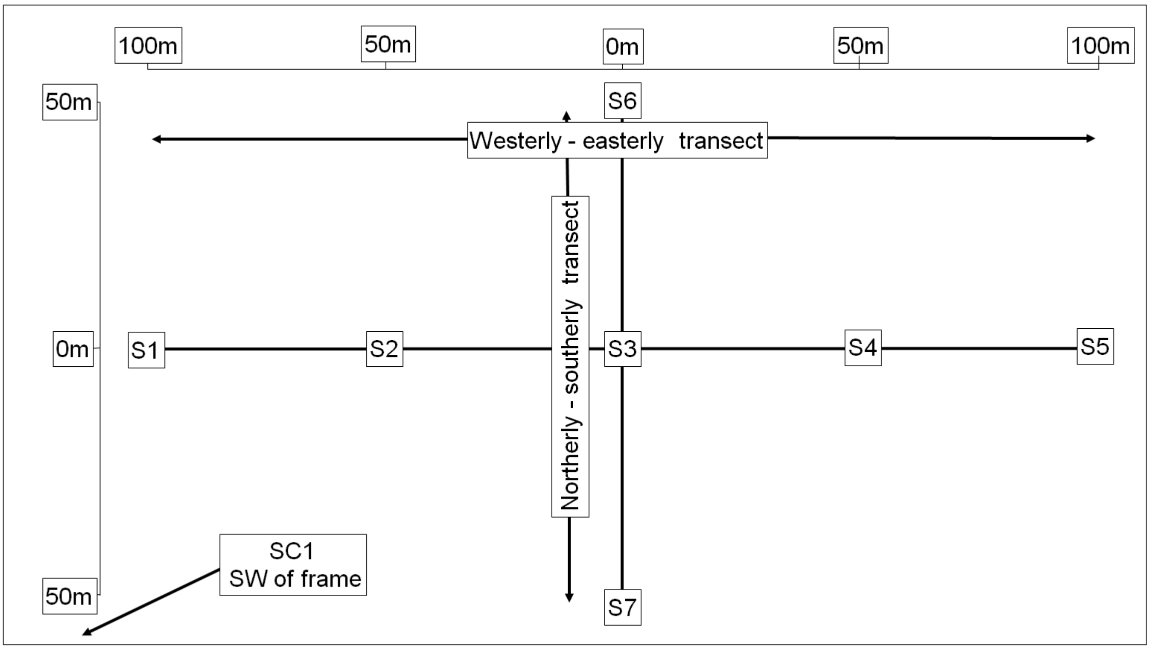
2.8. Benthic survey; physico-chemical analysis

A benthic survey was conducted at Shot Head on August 5th 2009. The intention was to sample at the site centre (see Figures 4 and 52) and then at 20m, 50m and 100m to the west and east of it (parallel to the main current axis, see Section 2.3.2) and at 20m and 50m to the north and south of it, perpendicular to the main current axis. However the site was too deep for the laying of seabed transects and, on the day, sea conditions were very turbulent, with strong westerly winds. The survey was therefore modified by omitting the sample sites 20m from the site centre point. Figure 51 summarises the sites from which samples were collected. Conditions also made it difficult to hold station for sampling and there was some drift from the intended sampling locations. Figure 52 shows the locations of the actual sites where samples were collected, while Table 8 gives their coordinates.

It should be noted that the seabed area proposed for grant of licence offers some flexibility for the positioning of the cage grid and that, therefore, the cage positions as described in Figure 52 and Table 8 are notional only. It is therefore submitted that, even though the sampling sites were slightly removed from their intended positions, they still offer a good basis on which to describe benthic conditions in the proposed site area.

It should also be noted that the site depth made a diver-executed photographic survey difficult since this could only be achieved with a helium-oxygen gas mix and offered limited time for the execution of the survey. In its place, it was decided to carry out ROV video surveys, as described in Section 2.12.

Figure 51.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Positions and numbers for benthic grab sample collection; sample sites S1 to S7.
Control site; 500-1000m from cage block in similar ground; sample site SC1.



2.8.1. Benthic physico-chemical analysis: methods;

Three benthic sediment samples were taken from each sample site, using a 0.045m^2 area Van Veen grab. Rock was encountered near site S2; see Table 8 and Figure 52. Such unsuccessful sample runs were rejected. All successful grab samples were returned full so can be compared in volume terms. Two complete grab samples were used for identification of infauna and the third was used to take one sample for particulate sand analysis and one sample for organic carbon analysis. Redox was measured in all three grabs collected at each site. The following physico-chemical analytical procedures were carried out:-

- Methods; particle size analysis (PSA)
  A 150ml sample of sediment was collected from the surface (0-2cm) of one grab sample at each station. Samples were stored in plastic pots and frozen within 24 hours of collection to await analysis. PSA was carried out by sieving. Approximately 200gm of sample was mixed with 500ml water and 200ml of a 7% solution of sodium hexametaphosphate. This mixture was stirred and then allowed to settle overnight prior to rinsing in distilled water. After stirring, each sample was then dried for 48 hours at 60ºC and then mechanically sieved through a BS standard sieve series.

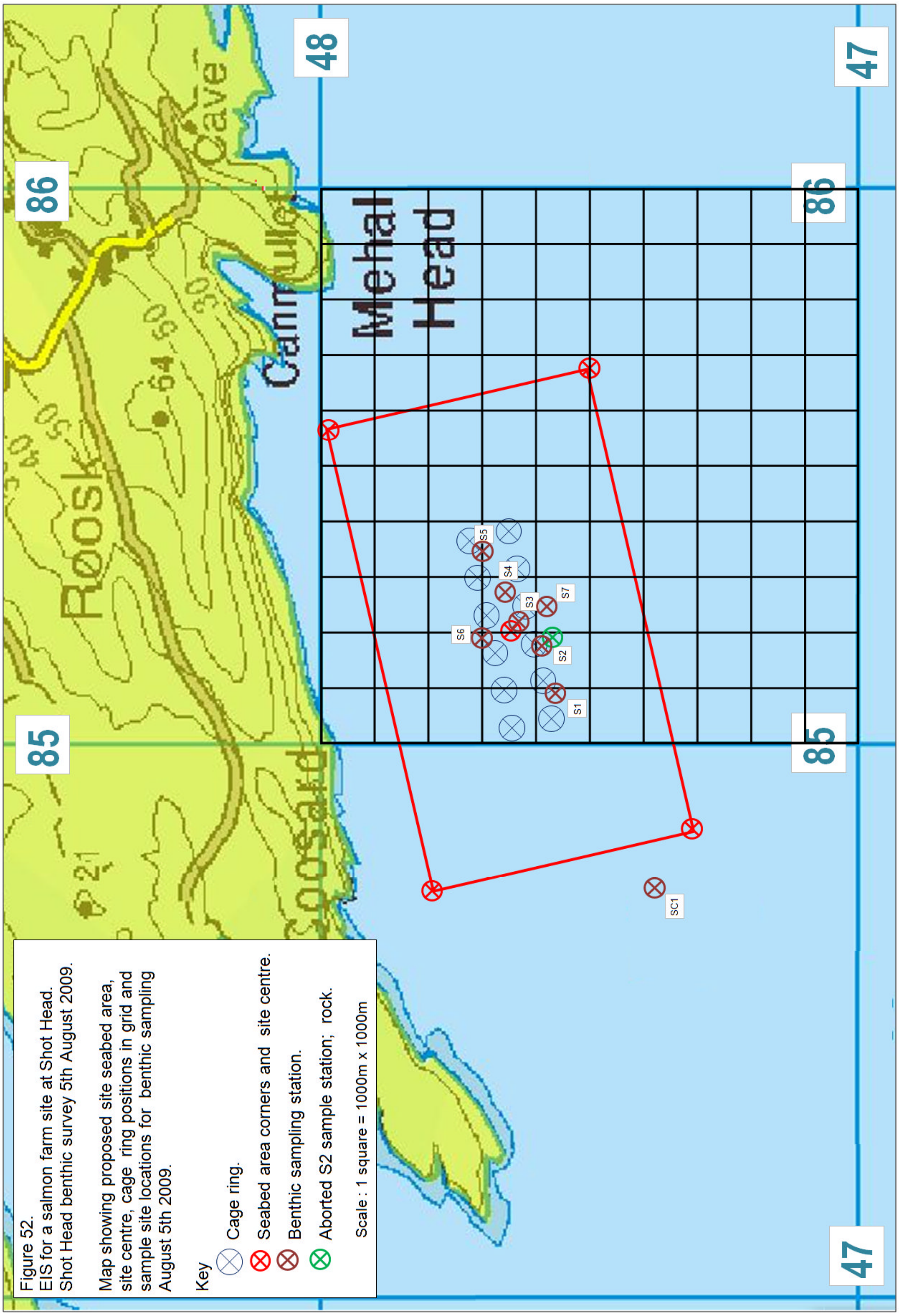


Figure 52.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.

Map showing proposed site seabed area, site centre, cage ring positions in grid and sample site locations for benthic sampling August 5th 2009.

Table 8.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Coordinates relevant to Shot Head surveys.

Location	Proposed seabed area coordinates	Irish National Grid coordinates E	N	Corner to corner distances m (Seabed area dimensions m)	
Site corners	NW	84737	47796	North side	850
	NE	85567	47980	East side	500
	SE	85675	47491	South side	850
	SW	84845	47308	West side	500
Site centre		85206	47644		

Cage	Approximate cage centre coordinates Read from Figure 52 map: Cage number	Irish National Grid coordinates E	N	Between-cage distances m	
North row cages 1-6	1	85030	47644		
	2	85098	47660	Cage 1-2	70
	3	85166	47676	Cage 2-3	70
	4	85233	47691	Cage 3-4	70
	5	85301	47707	Cage 4-5	70
	6	85368	47722	Cage 5-6	70
South row cages 7-12	7	85048	47570		
	8	85115	47586	Cage 7-8	70
	9	85183	47602	Cage 8-9	70
	10	85250	47618	Cage 9-10	70
	11	85317	47633	Cage 10-11	70
	12	85385	47649	Cage 11-12	70

Transect	Benthic sample site coordinates see Figure 52: Benthic sample site number	Irish National Grid coordinates E	N	Distance from sample site S3 m (centre site)	
Centre to west	S1	85095	47567	S1-S3	142.30
	S2a	85192	47576	Rock encountered moved NW	
	S2	85176	47592	S2-S3	61.52
	S3	85220	47635		
Centre to east	S4	85275	47660	S4-S3	60.42
	S5	85345	47700	S5-S3	140.89
Centre to north	S6	85193	47702	S6-S3	72.24
	S3	85220	47635		
Centre to south	S7	85250	47582	S7-S3	77.83
Control site	SC1	84738	47379	Site centre-SC1	545.77

Boatyard monitoring control site	75469	45592	

- Methods; redox potential.
  Redox potential is a qualitative not a quantitative measure, used as a means of comparison of the intensity of reducing conditions in samples of media such as marine sediments, on a site to site basis. In general, the more negative the redox, the lower the ability of the sediment to exchange electrons, thus impairing chemical reactions vital for the sediment to sustain life[17]. Redox potential can also be used an indicator of sulphide in sediments but not a concentration in that redox potential is always negative in the presence of sulphide and positive in its absence[18].

  Sediment redox potential was measured from all grab samples collected from each station, using a Russell KDCMPTB11 ORP electrode, connected to a Hanna Meter (HI 9625 Microcomputer). Redox was measured at 1cm intervals from the surface (1cm), to the sediment depth to which the probe could be easily inserted and obstruction to further insertion was encountered.

  The redox meter was calibrated against standard Zobell's solution, which has standard mV value of 247mV. All readings were adjusted to correct for disparity between the Zobell's standard and the meter reading, which was 234mV, therefore requiring a correction of 13mV. A further correction was added to calibrate the meter readings to the manufacturer's data for the probe, relative to the Standard Hydrogen Electrode value. This required the temperature of the sediments in the grab to be taken and a correction of +218 to be made (at a sediment temperature of 14ºC) .

- Methods; visual sediment description.
  Each sediment sample was visually assessed, prior to sample processing. Colour and texture were noted, along with presence or absence *Beggiatoa* mats and indications of out-gassing or hydrogen sulphide. These are standard visual descriptors for fish farm site sediments. However such descriptors are unlikely to be present at this site because it is not in use. Therefore no organic loading was expected at the site. The visual observation data nonetheless serves as a baseline, should the site be licensed and operated.

17 SEPA Baseline survey standard. September 2008.

18 Nissenbaum et al 1972. Early diagenesis in a reducing fjord, Saanich Inlet, B.C.-I. chemical and isotopic changes in major components of interstitial water: *Geochim. Cosmochim Acta,* v. 36, p.

- Methods; sediment chemistry
  At each station, a 100ml sub-sample of sediment was collected from the surface (0-2cm) of the grab sample used for the PSA sample. Samples were placed in airtight plastic pots. On return to the laboratory, samples were stored frozen to await analysis for organic carbon, using the Loss on Ignition method[19] at (450ºC).

2.8.2. Benthic physico-chemical analyses; results; .

- Results; Particle Size Analysis (PSA)
  PSA data for all sampling stations is tabulated by station in Figure 53. The graphs plot the percentage by dry weight of the particles retained on each sieve in the sieve series, for each sample. The PSA results indicate fairly homogeneous sediments in the site area, comprising, in the main, soft, clean sands with a variable admixture of gravels or larger particles and some silt. In particular, sediments from the middle to the west of the sampled area, between samples S1 and S4, show a consistent composition, which contained 30% to 40% of particles of over 2mm, comprising gravel with a small admixture of pebble and cobble, with the balance of the samples comprising mainly coarse to very coarse sands with shell fragments and a small admixture of silt.

  Samples S5 and S6 also bear some similarities in their relative lack of particles of greater than 2mm diameter and their fine to coarse sand content, although sample S5, taken from the eastern end of the site area contained 6% of silt. Silt was almost absent from sample S6, taken from the north of the centre of the sampled area.

  Sample S7, the most southerly sample collected, showed the least consistency with all other samples due to its 69% content of particles of greater than 2mm diameter, comprising cobble, pebble and gravel. The balance of the sample comprised coarse and very coarse sand, with virtually no particles of less than 425µ diameter.

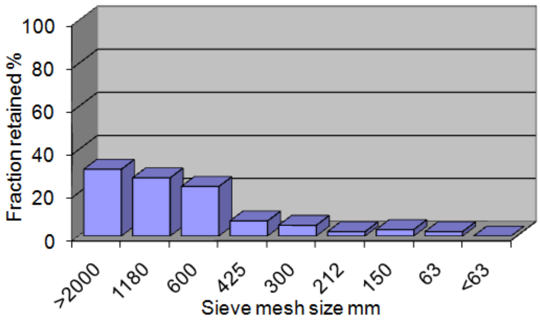
  The control station, sample SC1, collected some 540m southwest of the centre of the proposed site seabed area was somewhat similar in its composition to samples S5 and S6 in its relative lack of coarse materials. However, it contained a far higher silt level, of the order of 52%.

19 Allen et al 1974. Chemical analysis of ecological materials. Blackwell Scientific Publications, Oxford.

Figure 53 Sheet 1.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Particulate sand analysis (PSA) at sampling stations.

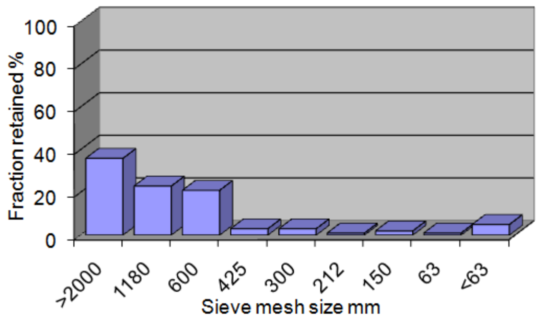
Sample S1

Sieve mesh µ	Fraction retained %	Appearance of dry sample Colour	Approximate composition
>2000	31.00	Grey	Gravel with small admix pebble and cobble
1180	27.00		Very coarse sand and shell fragments
600	23.00		Coarse sand and shell fragments
425	7.00		Medium sand wth shell fragments
300	5.00		Medium sand wth shell fragments
212	2.00		Fine sand
150	3.00		Fine sand
63	2.00		Very fine sand
<63	0.00		No silt or clay



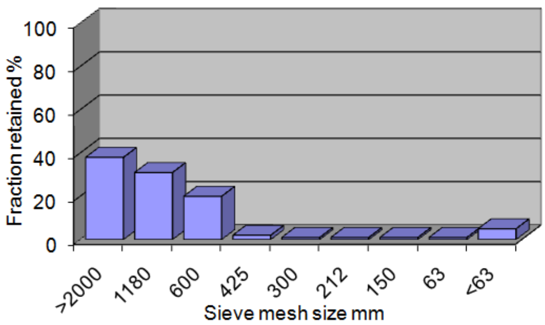
Sample S2

Sieve mesh µ	Fraction retained %	Appearance of dry sample Colour	Approximate composition
>2000	36.00	Grey	Gravel with admix of pebble and cobble
1180	23.00		Very coarse sand and shell fragments
600	21.00		Coarse sand and shell fragments
425	3.00		Small admix of medium sand
300	3.00		Small admix of medium sand
212	1.00		Small admix fine sand
150	2.00		Small admix very fine sand
63	1.00		Small admix fine sand
<63	5.00		Some silt



Sample S3

Sieve mesh mm	Fraction retained %	Appearance of dry sample Colour	Approximate composition
>2000	38.00	Grey	Gravel with small admix pebble and cobble
1180	31.00		Very coarse sand and shell fragments
600	20.00		Coarse sand and shell fragments
425	2.00		Small admix of medium sand
300	1.00		Small admix of medium sand
212	1.00		Small admix fine sand
150	1.00		Small admix very fine sand
63	1.00		Small admix fine sand
<63	5.00		Some silt



Sample S4

Sieve mesh mm	Fraction retained %	Appearance of dry sample Colour	Approximate composition
>2000	40.00	Grey	Gravel with small admix pebble and cobble
1180	26.00		Very coarse sand and shell fragments
600	21.00		Coarse sand and shell fragments
425	2.00		Small admix of medium sand
300	3.00		Small admix of medium sand
212	0.00		Small admix fine sand
150	1.00		Small admix very fine sand
63	1.00		Small admix fine sand
<63	6.00		Some silt

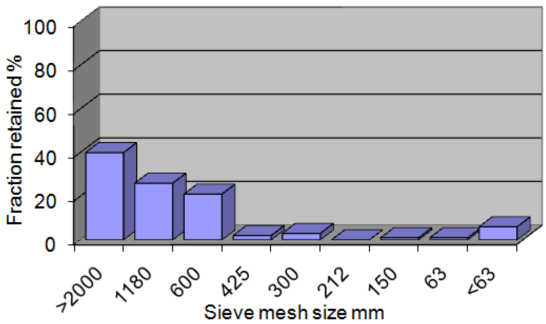
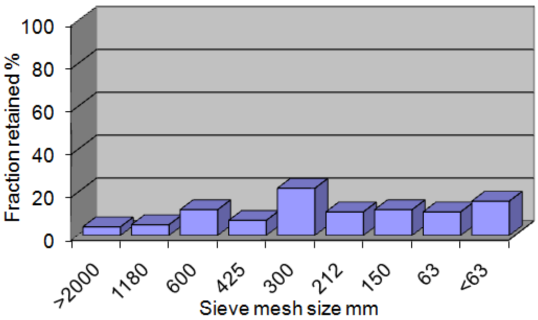


Figure 53 Sheet 2.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Particulate sand analysis (PSA) at sampling stations.

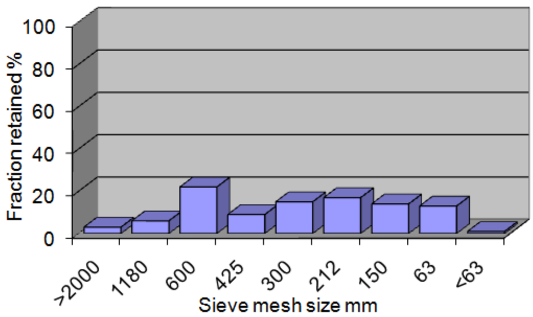
Sample S5

Sieve mesh µ	Fraction retained %	Appearance of dry sample	
		Colour	Approximate composition
>2000	4.00	Grey	Small admix of gravel
1180	5.00		Smalll admix very coarse sand
600	12.00		Some coarse sand
425	7.00		Some medium sand
300	22.00		Medium sand
212	11.00		Fine sand
150	12.00		Fine sand
63	11.00		Very fine sand
<63	16.00		Silt



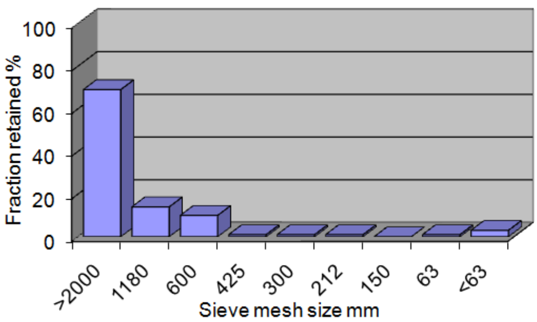
Sample S6

Sieve mesh µ	Fraction retained %	Appearance of dry sample	
		Colour	Approximate composition
>2000	3.00	Grey	Small admix of gravel
1180	6.00		Smalll admix very coarse sand
600	22.00		Coarse sand
425	9.00		Some medium sand
300	15.00		Medium sand
212	17.00		Fine sand
150	14.00		Fine sand
63	13.00		Very fine sand
<63	1.00		Little silt



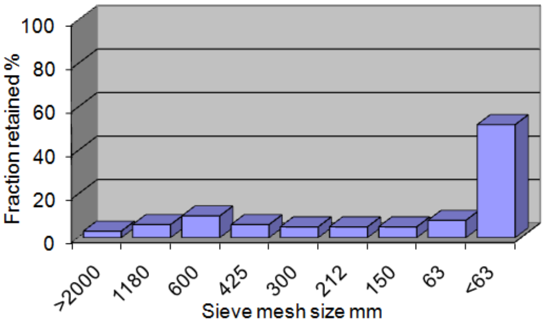
Sample S7

Sieve mesh mm	Fraction retained %	Appearance of dry sample	
		Colour	Approximate composition
>2000	69.00	Grey	Mainly cobble pebble and gravel
1180	14.00		Very coarse sand
600	10.00		Coarse sand
425	1.00		Little medium sand
300	1.00		Little medium sand
212	1.00		Little very fine sand
150	0.00		Little fine sand
63	1.00		Little fine sand
<63	3.00		Small admix silt



Sample SC1 (Control)

Sieve mesh mm	Fraction retained %	Appearance of dry sample	
		Colour	Approximate composition
>2000	3.00	Grey	Little gravel
1180	6.00		Some very coarse sand
600	10.00		Coarse sand
425	6.00		Some medium sand
300	5.00		Some medium sand
212	5.00		Some fine sand
150	5.00		Some fine sand
63	8.00		Some very fine sand
<63	52.00		Main constituent silt



- Results; redox potential (mV)

  Redox potential results, collected from the three grabs taken at all sample stations, are tabulated and graphed in Figure 54 (note that only two sets of redox data were collected from sample sites S1, S4 and S5). The depth to which redox data was collected was in the range of 6cm to 9cm, until some obstruction to further insertion, possibly a small cobble or similar, was encountered.

  Almost invariably, all samples collected within the site area gave positive redox results, in the range +124mV to +2mV, in a sediment depth range of 6cm to 9cm, decreasing steadily with insertion depth, as expected. This redox range is indicative of medium to coarse, clean, oxygenated substrates and showing no discontinuity layer within the measurable depth of substrate[20].

  Note that a positive trend in redox potential profiles is generally indicative of clean sediments with good water / oxygen exchange and aerobic rather than reducing conditions and consequent lack of out-gassing and hydrogen sulphide smell. Thus the readings given are consistent with the observations in the visual assessment of the sediment samples taken; see Table 9.

  The only exceptions to these observations of positive redox were seen in single replicates at sample stations S2 and S3, which showed a discontinuity layer at about 7cm depth and a redox at 8cm of -5mV and -37mV respectively. In a largely positive redox profile, such negative readings indicate no more than a very localised occurrence of anoxia, more likely than not caused by a decaying organism.

  The most positive redox profiles were given by all three replicates at sample station S7, where particulate sand analysis (see Figure 53) indicated the coarsest sediment particles and therefore, in all likelihood, best water / oxygen exchange.

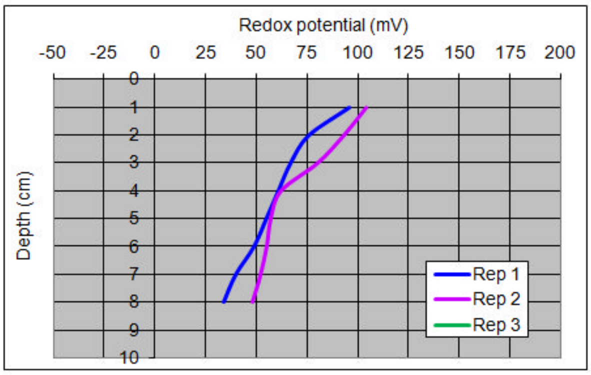
  Redox data for the control site, SC1 shows a slightly different redox profile in two replicates, falling from +99mV to a minimum of -15mV, with the discontinuity layer at 5cm to 7cm over a 7cm to 8cm profile depth The redox profile in the replicate 3 was positive throughout. In clean sediments a trend of negative readings is generally characteristic of finer sediments with little water / oxygen exchange likely, as found at this site; see Figures 53 and 54.

[20] The discontinuity layer is the point where redox readings change from positive to negative.

Figure 54 Sheet 1.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Redox potential mV at sampling stations.

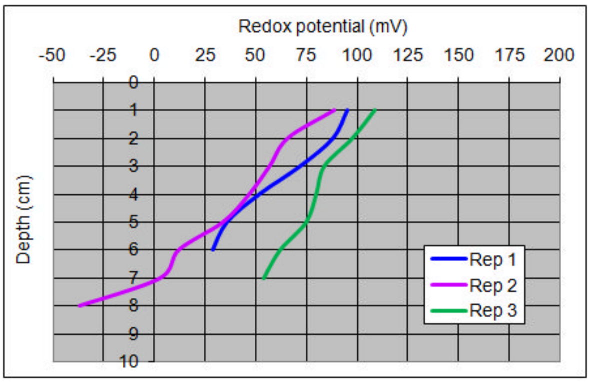
Station S1

Depth cm	Redox potential mV		
	Rep 1	Rep 2	Rep 3
1	96.0	104.0	
2	76.0	93.0	
3	67.0	80.0	
4	61.0	62.0	
5	55.0	57.0	
6	49.0	55.0	
7	40.0	52.0	
8	34.0	48.0	
9			
10			



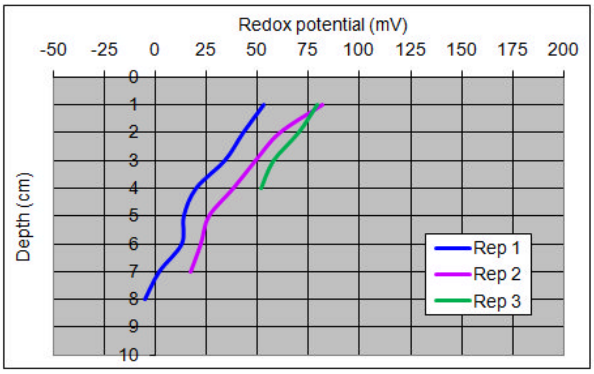
Station S2

Depth cm	Redox potential mV		
	Rep 1	Rep 2	Rep 3
1	95.0	89.0	109.0
2	88.0	66.0	98.0
3	72.0	57.0	84.0
4	52.0	47.0	80.0
5	36.0	34.0	75.0
6	29.0	12.0	62.0
7		3.0	54.0
8		-37.0	
9			
10			



Station S3

Depth cm	Redox potential mV		
	Rep 1	Rep 2	Rep 3
1	53.0	82.0	79.0
2	43.0	61.0	70.0
3	34.0	49.0	58.0
4	20.0	38.0	52.0
5	14.0	26.0	
6	13.0	22.0	
7	2.0	17.0	
8	-5.0		
9			
10			



Station S4

Depth cm	Redox potential mV		
	Rep 1	Rep 2	Rep 3
1	99.0	71.0	
2	91.0	58.0	
3	86.0	53.0	
4	77.0	45.0	
5	70.0	42.0	
6	61.0	38.0	
7	57.0	34.0	
8	53.0	17.0	
9			
10			

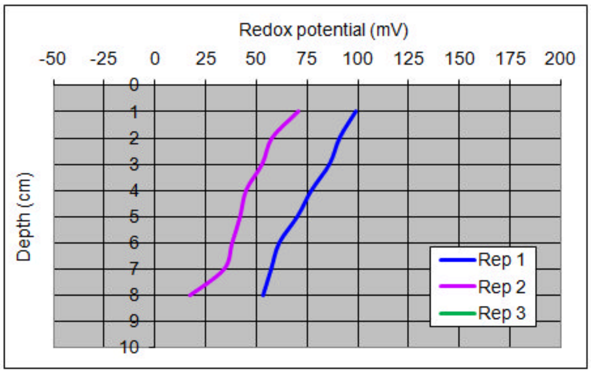
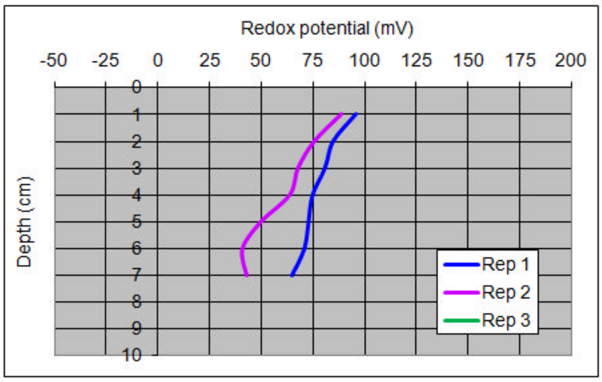


Figure 54 Sheet 2.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Redox potential mV at sampling stations.

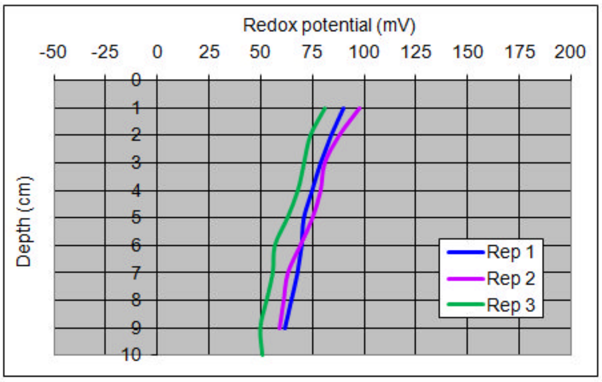
Station S5

Depth	Redox potential mV		
cm	Rep 1	Rep 2	Rep 3
1	96.0	89.0	
2	85.0	76.0	
3	81.0	68.0	
4	75.0	64.0	
5	73.0	50.0	
6	71.0	41.0	
7	65.0	43.0	
8			
9			
10			



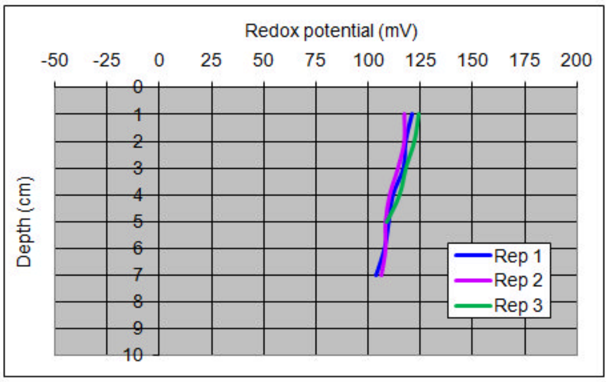
Station S6

Depth	Redox potential mV		
cm	Rep 1	Rep 2	Rep 3
1	90.0	98.0	81.0
2	84.0	88.0	74.0
3	79.0	81.0	71.0
4	75.0	79.0	68.0
5	71.0	75.0	63.0
6	70.0	69.0	57.0
7	68.0	63.0	56.0
8	65.0	61.0	53.0
9	62.0	59.0	50.0
10			51.0



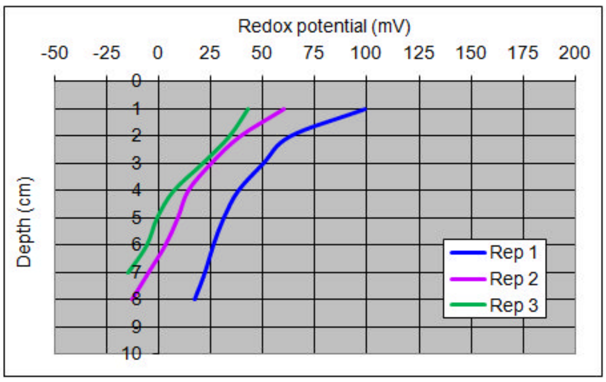
Station S7

Depth	Redox potential mV		
cm	Rep 1	Rep 2	Rep 3
1	121.0	117.0	124.0
2	118.0	117.0	122.0
3	117.0	114.0	118.0
4	112.0	110.0	115.0
5	110.0	108.0	109.0
6	108.0	108.0	
7	104.0	106.0	
8			
9			
10			



Station SC1 (Control station)

Depth	Redox potential mV		
cm	Rep 1	Rep 2	Rep 3
1	99.0	60.0	43.0
2	63.0	39.0	34.0
3	50.0	25.0	21.0
4	38.0	14.0	7.0
5	31.0	9.0	-1.0
6	26.0	3.0	-6.0
7	22.0	-5.0	-15.0
8	17.0	-13.0	
9			
10			



- Results; visual sediment description
  Visual sediment descriptions for the grab samples collected at the proposed Shot Head site are given in Table 9. Initial attempts at grab collection in the vicinity of sample station S2 gave indications of a rocky area some 100m SW of the proposed seabed area site centre; see Table 8 and Figure 52. This is further discussed in Sections 2.3.1 and 2.12; see also Figure 20. Other than this, visual observations of the grab samples collected indicate fairly homogeneous seabed conditions, comprising soft, grey sediments, free of attached alga and detritus (such as loose alga).

  The sediments in the site area were observed to be grey and sandy for the most part, with varying amounts of coarser particles, shell and silt, with no widespread signs of organic loading or the blackening, out-gassing or hydrogen sulphide smell normally associated with it. The overall impression is of natural clean sediments, consistent with other observations, namely redox profiles, sand analysis and organic carbon analysis, carried out as part of this survey. The grey colour of the benthic sediments in the area, including that thrown up on local beaches, is typical of the sandstone bedrock around the bay.

- Results; organic carbon analysis
  Organic carbon results are given in Figure 55. These data confirm the findings of the sediment visual assessment and redox results, in that the percentage of organic carbon in the samples collected in the site area is generally low, indicating absence of exogenous organic enrichment. Presence of exogenous organic carbon is not generally indicated by organic carbon levels of less than 5%. In this case, the highest reading was 2.7%, suggesting that the organic carbon content of the sediments is fully accounted for by the natural organic carbon content of flora and fauna contained in the samples.

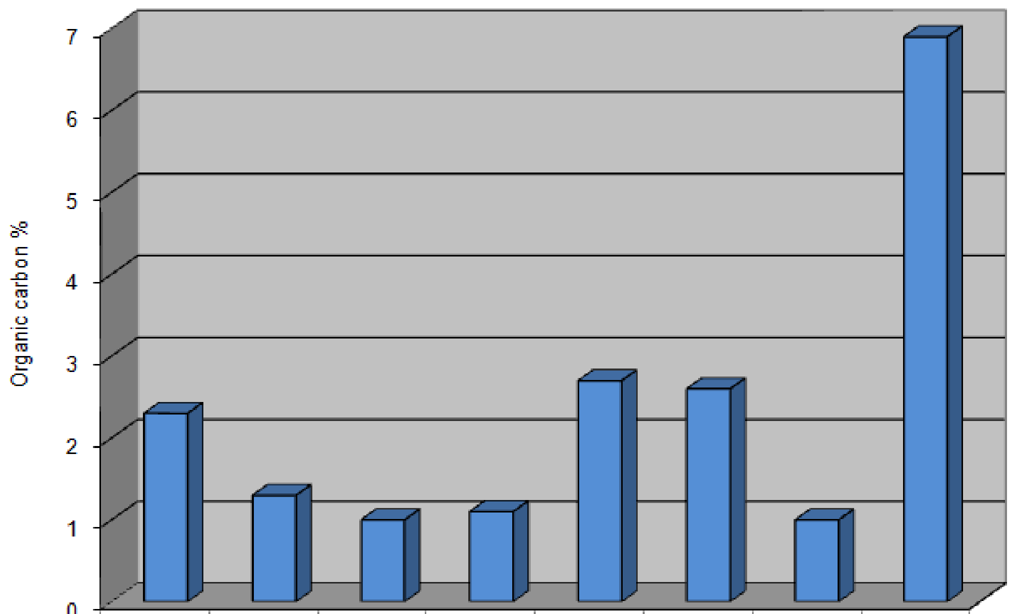
  Control site SC1 is the exception to this trend, where organic carbon percentage is 7%. However this is still a low reading and may just be a reflection of the finer sediments and consistent with slightly lower redox profiles than found in the coarser sediment samples collected within the site area itself.

  Overall there is an observable trend amongst all samples that organic carbon level tends to be lower in the coarser sediment samples and higher in the finer samples.

Table 9.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Visual sediment description of wet samples.

Sample Station	Distance from centre site S3 m	Time	Depth m	Colour	Texture	Sulphide smell	Out-gassing	*Beggiatoa* mat	Waste feed or faeces	Organic waste depth m	Sediment description
S1	142m west	10:10	39.6	Grey	Soft	No	No	No	No	0	Very gravelly SAND with shell fragments
S2	65m west	09:45	35.7	Grey	Soft	No	No	No	No	0	Slightly silty very gravelly SAND
S3	Site centre			Grey	Soft	No	No	No	No	0	Slightly silty very gravelly SAND
S4	60m east	09:15	40.0	Grey	Soft	No	No	No	No	0	Slight silty very gravelly SAND
S5	141m east	10:30	38.8	Grey	Soft	No	No	No	No	0	Slighly gravelly very silty SAND
S6	72m north			Grey	Soft	No	No	No	No	0	Slighly silty slighty gravelly SAND with shell fragments
S7	77m south			Grey	Soft	No	No	No	No	0	Slighly silty very sandy GRAVEL with shell fragments
SH1	546m SW	12:20	40.1	Grey	Soft	No	No	No	No	0	Slighly gravelly very sandy SILT

Figure 55.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Percent organic carbon at sampling stations.



	S1	S2	S3	S4	S5	S6	S7	SC1
Carbon %	2.30	1.30	1.00	1.10	2.70	2.60	1.00	6.90

2.9. Benthic survey methods; macrofaunal analysis.

2.9.1. Methods; raw data collection and handling

Two separate grab samples were collected from each sampling station for macrofaunal analysis. Each sample was washed on site with seawater over a 1mm sieve. The retained material, including infauna, was transferred to a 1 litre plastic container and fixed in a 40% borax-buffered formaldehyde solution. This was then diluted two-to-three-fold with seawater to give 15-20% formaldehyde solution. On return to the laboratory, the samples were transferred to trays and sorted. The contained macrofauna was removed and stored in vials containing a solution of 70% IMS (Industrial methylated spirit or denatured alcohol) , 20% glycerol and 10% water. The macrofauna were then identified to the lowest taxonomic level possible and counted.

Univariate and multivariate analyses were performed on the collected numerical data, using PRIMER v5[21] software. PRIMER v5 is a range of univariate, graphical and multivariate routines for analysing matrices of species by their abundances in samples (or similar measure) that arise in the biological monitoring of environmental impact and related studies. In this case, a number of univariate and multivariate analytical routines were selected from those offered by PRIMER v5 which were felt to be suitable for the present case, as follows:-

2.9.2. Methods; univariate analyses

The following univariate analyses were carried out, to assess population size, diversity or evenness of distribution and pollution-related community status for each station. With the exception of ITI, which is manually generated by the application of the formula given below, all other indices are automatically generated by PRIMER v5 from the infaunal data input into the software.

- Number of Individuals (Abundance).
  Only useful if sample volumes are very similar, as in this case.

- Number of species or taxa.
  Similarly most useful where samples are of very similar volume and less so if sample volumes are very different.

- Margalef's Species Richness Index (SR).
  This index is expressed by the formula : $SR = (S - 1)/ \ln N$

[21] Plymouth Routines in Multivariate Ecological Research, Clarke KR and Gorley RN, Version v5, 2001.

Where S is the number of species and N is the number of individuals in the sample. This index provides a measure of species richness (or diversity) that is roughly normalised for sample size without the need to use more complex rarefaction techniques. The greater the species richness (in the range of 0 to 10) the greater the diversity. In general, the greater the species richness / diversity, the less polluted the environment from which samples were collected is likely to be.

- Shannon-Wiener Diversity Index (H').
  This index is expressed by the formula : $H' = -\Sigma (P_i \times \ln P_i)$

  Where P_i is the proportion of each species in the sample. The Shannon-Wiener Index provides a rough measure of diversity which is much less biased by sample size that species richness alone (Margalef's Species Richness Index). Maximum diversity, that is when the population is perfectly heterogeneous (when every species in a sample is present in equal numbers) is indicated by a Shannon Index value of about 3.5 or up to 4.7 for very large samples. A value close to zero occurs when the population is perfectly homogenous, that is when there is a single species present. Middle of the range scores (say around 1.50) can be ambiguous, which can make Shannon Wiener Index values difficult to interpret.

- Pielou's Evenness Index (J').
  This index is expressed by the formula : $J' = H' / H'_{max}$

  Pielou's index is derived from the Shannon-Wiener Index. It is also a diversity index, where H' is the Shannon-Wiener Index value and where H'max = lnS, S being the number of species in the sample. Pielou's Index determines how evenly the proportions of the taxa present are distributed in a sample. A minimum value of 0 occurs when variation is at is greatest and the maximum value of 1 occurs when the every species present is equally represented, that is perfectly even.

- Infaunal Trophic Index (ITI; Codling and Ashley 1992[22]).
  ITI is unlike and of the above biological indexing methods in that, rather than simply ranking or discriminating between sites on the basis of arithmetic differences in the populations present, it ranks sites on the basis of biological features of infaunal distribution. ITI helps to describe pollution gradients from sewerage and industrial discharges and temporal changes in pollution levels, on the basis of the taxa present.

[22] Codling ID and Ashley SJ. 1992. Development of a biotic index for the assessment of pollution status of marine benthic communities, Water Research Council Report No. SR 2995, Marlow, Bucks SL7 2HD, UK.

To achieve this, benthic invertebrates are divided into four *trophic groups*, based on the type of food they eat and how it is obtained:-

Trophic Group 1 : suspension / filter feeders), such as *Mya arenaria.*
Trophic Group 2 : surface detritus feeders such as *Glycera lapidum*.
Trophic Group 3 : surface deposit feeders such as *Nephthys cirrosa.*
Trophic Group 4 : sub–surface deposit feeders such as *C. capitata*.

ITI was first developed in the US (Word 1978[23]) for the analysis of soft sediment communities, such as those at Shot Head. It was adapted for UK waters in 1992 by Codling and Ashley. This latter classification is employed here. The formula for the derivation of ITI is as follows:-

$$ITI = 100 – [33.3 \{(0N_1 + N_2 + 2N_3 + 3N_4) / (N_1 + N_2 + N_3 + N_4)\}]$$

where, for a given sample station, N_1 is the number of animals in Trophic Group 1, N_2 is the number of animals in Trophic Group 2, N_3 is the number of animals in Trophic Group 3 and N_4 is the number of animals in Trophic Group 4. The range of ITI values is between 0 and 100. Fairly obviously, if only if only specialised filter feeders (ITI Group 1) are present, the index score is 100:-

$$ITI = 100 - (33.3 \times (0)) = 100.$$

Whereas if only organic deposit feeders (ITI Group 4) are present, the index score is zero:-

$$ITI = 100 - (33.3 \times (3)) = 0.$$

When a mix of trophic types are present, the ITI score varies accordingly. ITI only gives an approximate indication of pollution status but the following guidelines apply[24]:-

ITI score	Pollution status
50 - 100	Community normal (minimal organic pollution present).
20 - 50	Community changed (some organic pollution present).
<20	Community degraded (high organic pollution present).

[23] Word JQ. 1978. The Infaunal Trophic Index, Annual Report 1978. Coastal Water Research Project, El Segundo, CA, USA, pp. 19-39.

[24] ECASA (Ecosystem approach to Sustainable Aquaculture) definitions (EU-funded EU research program) general definitions from sea loch datasets, www.ecasa.org.uk.

2.9.3. Methods; multivariate analyses

The multivariate analyses employed do not assess any biological or environmental aspect of infaunal distribution. They simply rank or discriminate between sites on the basis of arithmetic differences in the populations present. Thus they offer an entirely objective assessment of differences or similarities between samples. Multivariate analysis of raw infaunal sample data is a useful tool because it can be used to give arithmetic confirmation of the degree to which sites differ, as defined by biotic assessments such as ITI. The two multivariate analyses executed here, Bray Curtis Similarity and Multidimensional Scaling (MDS) are generated automatically, from infaunal numerical data (see Table 10) input into the PRIMER v5 program.

2.10. Benthic survey results; macrofaunal analysis.

2.10.1. Benthic survey results; raw benthic macrofauna data.

Aggregate taxonomy and enumeration data for the macrofauna found in the two grabs collected at each sampling station are given in Table 10, along with a breakdown of taxa by ITI Trophic Group (bottom of Table 10, Sheet 2). There were a total of 87 taxa between all sample sites. However the number of taxa per site varies from 22 at SC1 (where the sediments were the finest) to 41 at sample station S7 (with the coarsest sediments).

The raw data indicate a number of common features between the sites investigated, to a greater or lesser degree. Five species were present, in common to dominant numbers, at all sites barring S7, where low numbers or, in one case no specimens of these species occurred. These are enumerated in Table 11. These five species account for between 77% and 92% of all taxa found at the sites in question, whilst they account for only 9% of the taxa at site S7. The ophiuroid echinoderm, *Amphiura filiformis*, is th emost notable, accounting for 41% to 62% of all specimens identified at these sites, relative to less than 5% at site S7.

Again, notably, of the 41 species present at site S7, four occur in only one other sample and 18 are not present at all in any other sample. These 18 taxa are enumerated in Table 12. They include the two most common species at site S7, the Echinoderms *Ophiura ophiura* (52 specimens) and *Ocnus lacteus* (98 specimens) which, together, contribute 48% to the total specimen count at site S7.

Table 10 Sheet 1.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Animal numbers by species in benthic samples and ITI classification by trophic group.

Phylum	Genus	Species	ITI group	Animal numbers per sample station							
				S1	S2	S3	S4	S5	S6	S7	SC1
CNIDARIA	*Hydrozoa*	*sp*	1	0	0	0	0	0	1	0	0
	Cerianthus	*lloydii*	3	0	0	0	0	0	0	1	0
	Edwardsia	*sp*	3	0	0	0	0	1	0	1	0
NEMERTEA	*Nemertea*		3	4	0	0	4	1	1	4	2
	Tubulanus	*polymorphus*	3	2	1	1	2	3	3	2	0
	Cerebratulidae		3	0	1	0	0	0	0	0	0
SIPUNCULIDA	*Golfingia*	*sp*	2	0	0	0	0	0	0	0	1
	Thysanocardia	*procera*	2	2	0	1	1	0	0	0	0
PLATYHELMINTHES	*Turbellaria*		3	0	0	1	0	0	0	0	1
ANNELIDA	*Pisione*	*remota*	3	0	0	0	0	0	0	1	0
	Harmothoe	*glabra*	3	1	3	2	0	0	3	2	0
	Pholoe	*baltica*	3	6	38	27	95	41	36	2	18
	Anaitides	*maculata*	3	0	0	1	0	0	0	0	0
	Anaitides	*rosea*	3	0	0	0	0	0	0	4	0
	Eteone	*longa*	3	0	0	0	0	0	0	9	0
	Eumida	*bahusiensis*	3	1	0	0	1	0	0	3	0
	Glycera	*alba*	3	0	2	0	0	2	2	0	1
	Glycera	*gigantea*	2	0	0	1	0	1	2	0	0
	Glycera	*rouxii*	3	0	0	1	0	2	2	9	0
	Goniada	*maculata*	3	2	0	0	0	0	1	1	0
	Aglaophamus	*rubella*	3	0	0	0	0	0	0	1	0
	Nephtys	*hombergi*	3	0	0	4	0	1	0	0	0
	Nephtys	*incisa*	3	2	0	0	0	0	0	0	5
	Nephtys	*kersivalensis*	3	1	3	0	0	0	0	0	0
	Glyphohesione	*klatti*	3	0	0	1	0	0	0	0	0
	Ophiodromus	*flexuosus*	2	5	1	0	0	5	3	5	7
	Exogone	*sp*	2	0	0	0	1	0	0	18	0
	Abyssinonae	*hibernica*	3	1	1	1	1	0	0	0	0
	Lumbrineris	*gracilis*	3	18	20	12	16	26	18	4	1
	Protodorvillea	*kefersteini*	4	0	0	0	0	0	0	8	0
	Aponuphis	*bilineata*	3	0	0	0	0	0	0	2	0
	Paradoneis	*sp*	2	0	0	0	0	0	0	2	0
	Aonides	*paucibranchiata*	2	0	0	1	0	0	0	4	0
	Laonice	*cirrata*	2	0	0	1	0	0	0	6	0
	Minuspio	*cirrifera*	2	0	4	1	0	0	2	0	0
	Minuspio	*multibranchiata*	2	0	2	0	0	0	2	0	0
	Spiophanes	*bombyx*	1	4	0	0	0	0	0	0	0
	Spiophanes	*kroyeri*	1	2	1	0	0	1	1	0	0
	Magelona	*alleni*	2	1	0	0	0	0	0	0	0
	Caulleriella	*alata*	2	0	0	0	0	0	1	2	0
	Monticellina	*sp*	2	0	4	1	0	4	2	0	0
	Chaetozone	*gibber*	2	1	1	0	1	0	1	0	0
	Tharyx	*killariensis*	2	0	0	0	0	1	1	0	3
	Diplocirrus	*glaucus*	2	25	2	2	8	6	2	0	13
	Capitella	*sp*	4	0	0	0	0	1	0	0	0
	Mediomastus	*fragilis*	3	0	1	1	0	0	0	10	0
	Notomastus	*sp*	4	1	0	2	0	0	0	0	0
	Heteroclymene	*robusta*	4	1	0	0	0	0	0	0	0

Table 10 Sheet 2.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Animal numbers by species in benthic samples and ITI classification by trophic group.

Phylum	Genus	Species	ITI group	Animal numbers per sample station							
				S1	S2	S3	S4	S5	S6	S7	SC1
ANNELIDA continued	*Praxillella*	*affinis*	2	0	0	0	0	1	0	0	0
	Scalibregma	*inflatum*	2	109	91	53	32	70	74	7	82
	Owenia	*fusiformis*	2	0	0	0	2	0	0	0	1
	Melinna	*palmata*	3	6	0	0	0	9	1	0	6
	Pectinaria	*auricoma*	3	2	0	0	2	0	1	0	0
	Pectinaria	*koreni*	3	1	0	0	1	0	0	0	1
	Pista	*cristata*	2	0	0	0	0	0	0	1	0
	Terebellides	*stroemi*	2	1	1	1	0	1	0	0	0
	Polycirrus	*sp*	2	0	1	0	0	1	2	1	0
	Jasmineira	*caudata*	1	0	0	0	0	0	0	1	0
CRUSTACEA	*Ostracoda*		2	1	0	0	1	0	0	0	0
	Ampelisca	*brevicornis*	1	2	1	0	0	3	2	0	0
	Ampelisca	*diadema*	1	2	1	0	2	1	2	1	0
	Harpinia	*antennaria*	2	4	5	1	2	0	1	0	0
	Metaphoxus	*fultoni*	2	0	0	0	0	0	0	3	0
	Atylus	*swammerdami*	3	0	0	0	0	0	0	1	0
	Aora	*sp*	1	0	0	0	1	0	0	1	0
	Caprella	*sp*	1	0	0	0	1	0	0	0	1
	Conilera	*cylindracea*	2	0	0	0	0	0	0	1	0
	Tanaidacea		2	1	0	0	0	0	0	0	0
	Diastylis	*sp*	2	0	0	2	3	2	1	3	1
	Iphinoe	*serrata*	2	2	20	16	9	17	15	0	8
	Pontophilus	*trispinosus*	2	1	0	0	1	1	1	0	1
	Liocarcinus	*sp*	3	0	0	0	0	0	0	1	0
MOLLUSCA	*Hyala*	*vitrea*	2	0	0	1	0	0	0	0	0
	Cylichna	*cylindracea*	2	0	0	1	0	0	0	0	1
	Nucula	*nitidosa*	3	0	1	0	0	0	2	0	0
	Mysella	*bidentata*	2	3	0	0	0	0	0	0	0
	Phaxas	*pellucidus*	1	1	2	0	0	0	2	0	0
	Abra	*alba*	2	0	0	3	0	0	0	1	0
	Abra	*nitida*	2	1	1	0	0	0	1	0	0
PHORONIDA	*Phoronis*	*sp*	1	2	0	0	0	0	2	0	0
ECHINODERMATA	*Amphiura*	*chiajei*	2	1	0	0	4	7	1	7	6
	Amphiura	*filiformis*	1	154	210	177	309	230	209	15	120
	Ophiura	*ophiura*	2	0	0	0	0	0	0	52	0
	Leptosynapta	*bergensis*	2	2	3	3	0	4	3	0	0
	Ocnus	*lacteus*	1	0	0	0	0	0	0	98	0
	Thyone	*fusus*	1	0	0	0	1	4	1	16	1
CHAETOGNATHA	*Spadella*	*cephaloptera*	1	0	0	0	0	0	0	1	0
Total abundance per sample				376	422	320	501	447	405	312	281

	S1	S2	S3	S4	S5	S6	S7	SC1
Number ITI Group 1 species (taxa)	7	6	1	5	5	8	7	3
Number ITI Group 2 species (taxa)	16	13	16	12	14	18	15	11
Number ITI Group 3 species (taxa)	13	10	11	8	9	11	18	8
Number ITI Group 4 species (taxa)	2	0	1	0	1	0	1	0
Total number of all species (taxa) per sample	38	29	29	25	29	37	41	22

	S1	S2	S3	S4	S5	S6	S7	SC1
Percentage of ITI Group 1 species (taxa)	18.4	20.7	3.4	20.0	17.2	21.6	17.1	13.6
Percentage of ITI Group 2 species (taxa)	42.1	44.8	55.2	48.0	48.3	48.6	36.6	50.0
Percentage of ITI Group 3 species (taxa)	34.2	34.5	37.9	32.0	31.0	29.7	43.9	36.4
Percentage of ITI Group 4 species (taxa)	5.3	0.0	3.4	0.0	3.4	0.0	2.4	0.0
Total	100	100	100	100	100	100	100	100

Table 11.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Enumeration of infaunal species common at sample sites other than S7.

Phylum	Genus / Species	ITI group	Animal numbers per sample station							
			S1	S2	S3	S4	S5	S6	S7	SC1
ANNELIDA	*Pholoe baltica*	3	6	38	27	95	41	36	2	18
	Lumbrineris gracilis	3	18	20	12	16	26	18	4	1
	Scalibregma inflatum	2	109	91	53	32	70	74	7	82
CRUSTACEA	*Iphinoe serrata*	2	2	20	16	9	17	15	0	8
ECHINODERMATA	*Amphiura filiformis*	2	154	210	177	309	230	209	15	120
Total number per sample			289	379	285	461	384	352	28	229

Phylum	Genus / Species	ITI group	Percentage of total infaunal count per sample station							
			S1	S2	S3	S4	S5	S6	S7	SC1
ANNELIDA	*Pholoe baltica*	3	1.60	8.98	8.44	18.96	9.17	8.89	0.64	6.41
	Lumbrineris gracilis	3	4.79	4.73	3.75	3.19	5.82	4.44	1.28	0.36
	Scalibregma inflatum	2	28.99	21.51	16.56	6.39	15.66	18.27	2.24	29.18
CRUSTACEA	*Iphinoe serrata*	2	0.53	4.73	5.00	1.80	3.80	3.70	0.00	2.85
ECHINODERMATA	*Amphiura filiformis*	2	40.96	49.65	55.31	61.68	51.45	51.60	4.81	42.70
Total percentage of total infaunal count per sample			76.86	89.60	89.06	92.02	85.91	86.91	8.97	81.49

Table 12.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Enumeration of infaunal species occurring at sample site S7 only.

Phylum	Genus / Species	ITI group	Animal numbers per sample station							
			S1	S2	S3	S4	S5	S6	S7	SC1
CNIDARIA	*Cerianthus lloydii*	3	0	0	0	0	0	0	1	0
ANNELIDA	*Pisione remota*	3	0	0	0	0	0	0	1	0
	Anaitides rosea	3	0	0	0	0	0	0	4	0
	Eteone longa	3	0	0	0	0	0	0	9	0
	Aglaophamus rubella	3	0	0	0	0	0	0	1	0
	Protodorvillea kefersteini	4	0	0	0	0	0	0	8	0
	Aponuphis bilineata	3	0	0	0	0	0	0	2	0
	Paradoneis sp	2	0	0	0	0	0	0	2	0
	Pista cristata	2	0	0	0	0	0	0	1	0
	Jasmineira caudata	1	0	0	0	0	0	0	1	0
CRUSTACEA	*Metaphoxus fultoni*	2	0	0	0	0	0	0	3	0
	Atylus swammerdami	3	0	0	0	0	0	0	1	0
	Conilera cylindracea	2	0	0	0	0	0	0	1	0
	Liocarcinus sp	3	0	0	0	0	0	0	1	0
ECHINODERMATA	*Ophiura ophiura*	2	0	0	0	0	0	0	52	0
	Ocnus lacteus	1	0	0	0	0	0	0	98	0
CHAETOGNATHA	*Spadella cephaloptera*	1	0	0	0	0	0	0	1	0
Total number per sample			0	0	0	0	0	0	187	0

Phylum	Genus / Species	ITI group	Percentage of total infaunal count per sample station							
			S1	S2	S3	S4	S5	S6	S7	SC1
CNIDARIA	*Cerianthus lloydii*	3	0	0	0	0	0	0	0.32	0
ANNELIDA	*Pisione remota*	3	0	0	0	0	0	0	0.32	0
	Anaitides rosea	3	0	0	0	0	0	0	1.28	0
	Eteone longa	3	0	0	0	0	0	0	2.88	0
	Aglaophamus rubella	3	0	0	0	0	0	0	0.32	0
	Protodorvillea kefersteini	4	0	0	0	0	0	0	2.56	0
	Aponuphis bilineata	3	0	0	0	0	0	0	0.64	0
	Paradoneis sp	2	0	0	0	0	0	0	0.64	0
	Pista cristata	2	0	0	0	0	0	0	0.32	0
	Jasmineira caudata	1	0	0	0	0	0	0	0.32	0
CRUSTACEA	*Metaphoxus fultoni*	2	0	0	0	0	0	0	0.96	0
	Atylus swammerdami	3	0	0	0	0	0	0	0.32	0
	Conilera cylindracea	2	0	0	0	0	0	0	0.32	0
	Liocarcinus sp	3	0	0	0	0	0	0	0.32	0
ECHINODERMATA	*Ophiura ophiura*	2	0	0	0	0	0	0	16.67	0
	Ocnus lacteus	1	0	0	0	0	0	0	31.41	0
CHAETOGNATHA	*Spadella cephaloptera*	1	0	0	0	0	0	0	0.32	0
Total percentage of total infaunal count per sample			0	0	0	0	0	0	59.94	0

2.10.2. Benthic survey results; univariate analysis.

The univariate analyses were conducted on the aggregate grab data collected from the two grab samples at each site using the PRIMER (Plymouth Routines in Multivariate Ecological Research) v5 statistical software package. All successful grabs were full and direct comparison of results between samples can therefore be justified. The results of univariate analysis are tabulated at the bottom of Table 10 Sheet 2 and in Figure 56.

- Results; number of individuals (Animal Abundance).
  See Table 10 and Figure 56.2. Animal abundance varied from 281 (control station SC1 to 501 (sample station S4). These figure indicate high abundance in the site area, indicative of normal, clean conditions. A pointed out in Section 2.10.1 and illustrated in Table 11, whilst sample station S7 is very different in its infaunal composition than all other stations (which are all very similar), a small number of species dominate the infauna at all stations, although the make-up of these dominant groups vary considerably between that at station S7 and that at all other stations. As in the case of species abundance, this can only be a consequence of differences in the physico-chemical features of the sample stations.

- Results; number of species or taxa.
  See Table 10 and Figure 56.1. Of the total number of 87 species identified between all the samples, the number of species in the aggregate grab samples collected varied from 22 (SC1) to 41 (S7). These figures suggest quite high biodiversity and indicative of readily colonised, clean sediments in the survey area. However, as pointed out in Section 2.10.1, differences in the distribution of species in aggregate sample S7 relative to all other samples suggests considerable differences between the habitat available at that site and all other sites. This is probably related to the coarseness of the sediments at S7, as indicated by the PSA analysis and also reflected in redox profiles; see Section 2.8.2.

  Of the species identified, it is observed that the ITI group 1 taxa varied from 14% (SC1) to 22% (S6), the ITI group 2 taxa varied from 37% (S7) to 50% (SS1), the ITI group 3 taxa varied from 30% (S6) to 44% (S7) and the ITI group 4 taxa varied from 0% (S2, S4, S6 and SC1) to 5% (S1). Notably therefore, species most indicative of organic loading and reducing sediment conditions (that is unfavourable conditions) are very poorly represented in the survey area.

- Results; Magalef's Species Richness Index
  See Table 10 and Figure 56.3. Results lie in the range of 3.72 (control station SC1) to 6.97 (sample station S7). As an expression of the number of species, relative to the number of individuals present in the samples and given the total index range 0 to 10, the range for these results is regarded as satisfactory and do not indicate environmental stress in at the sampling locations.

- Results; Shannon Wiener Diversity Index
  See Table 10 and Figure 56.4. This index measures the degree of difficulty in predicting the identity of the next animal in a sample. It thus takes account of species richness as well the proportion of each species present. The Shannon-Wiener indices for the samples tested lie in the range 1.39 (sample S4) to 2.67 (sample S7). These would be regarded as mid-range, in a nominal range between 0 (when only one species is present) and about 4.5 (when many species are all equally represented, suggesting a good range of species but with some rather more common than others). The extremes of the range found in the survey area demonstrate this. Station S4 has the lowest index and is, despite the highest animal abundance amongst the samples (501), heavily dominated by its population of *Amphiura filiformis* (>60% of abundance), whilst S7 has the highest index and the lowest abundance (312), but shows no similarly dominant individual taxa. Taken along with the findings of other univariate analyses, these results suggest generally good infaunal diversity, with no real sign of environmental stress in the survey area.

- Results; Pielou's Evenness Index
  See Table 10 and Figure 56.5. Pielou's Evenness Indices for the samples tested lie in the range 0.43 (sample S4) to 0.72 (sample S7), out of a total index range of 0 (maximum variation amongst taxa, that is dominance by one species) to 1 (completely even numbers of all taxa; that is no dominance at all). As for the Shannon Wiener Index, these results reflect previous observations that, amongst the majority of samples (S1 to S6 and SC1), where *Amphiura filiformis* dominates the infauna to a greater or lesser degree (41% to 62%), sample S4 is the site at which it was most dominant. At S7, on the other hand, the highest proportion of any species is 31% and this is reflected by an index considerably higher than at any other site (see Tables 11 and 12 and Figure 56). It should be noted that *Amphiura filiformis* frequently occupies this position of relative dominance in coarse sand to muddy sediments.

Table 13.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Univariate infaunal indices.

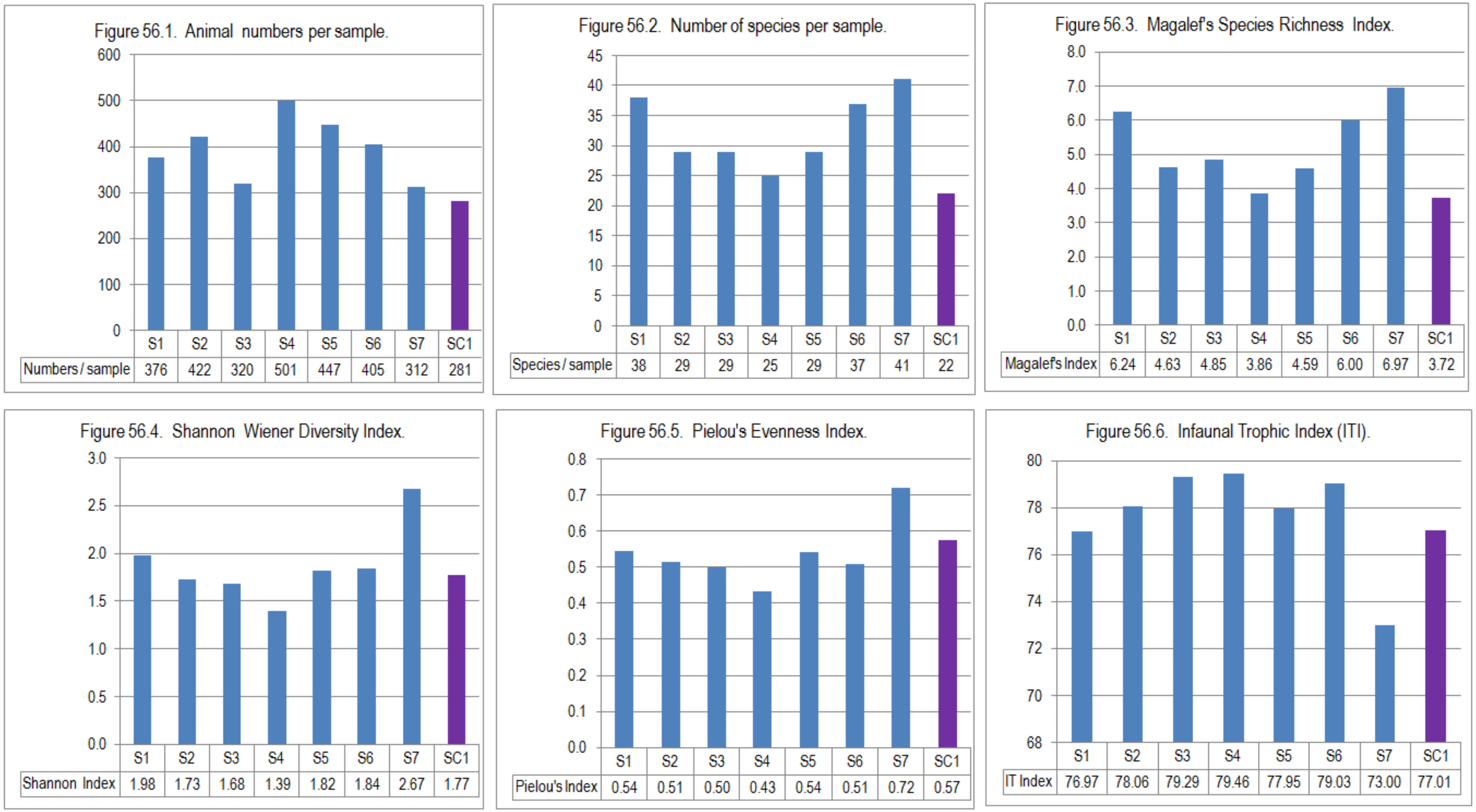
For calcuation of ITI	Sample station							
	S1	S2	S3	S4	S5	S6	S7	SC1
Abundance ITI Group 1 specimens	167	215	177	314	239	220	133	122
Abundance ITI Group 2 specimens	160	136	89	65	121	115	113	124
Abundance ITI Group 3 specimens	47	71	52	122	86	70	58	35
Abundance ITI Group 4 specimens	2	0	2	0	1	0	8	0

Univariate Indices; see Figure 56.	Sample station							
	S1	S2	S3	S4	S5	S6	S7	SC1
Total abundance per sample	376	422	320	501	447	405	312	281
Total species (taxa) / sample	38	29	29	25	29	37	41	22
Magalef's Index Richness	6.24	4.63	4.85	3.86	4.59	6.00	6.97	3.72
Shannon-Wiener Diversity Index	1.98	1.73	1.68	1.39	1.82	1.84	2.67	1.77
Pielou's Evenness Index	0.54	0.51	0.50	0.43	0.54	0.51	0.72	0.57
Infaunal Trophic Index (ITI	76.97	78.06	79.29	79.46	77.95	79.03	73.00	77.01

- Results; Infaunal Trophic Index (ITI).
  See Tables 10, 13 and Figure 56.6. ITI amongst the in-site samples varied from 73 (S7) to 79 (S3 and S6). The ITI for the control site is within this range at 77. These results fall well up the "normal" condition scale for ITI (that is "unchanged" due to lack of organic pollution). This is regarded as a satisfactory (and expected) result, consistent with the other findings of the univariate analyses. The ITI results are high primarily as the result of a lack of ITI Group 4 taxa. As tabulated at the bottom of Table 9, only four were identified and, as shown in Table 12, no more than 2 specimens occurred in any sample with the exception of sample S7 where a total of eight specimens of one species were counted. Indeed samples S2, S4, S6 and SC1 have no Trophic Group 4 taxa present at all. The lowest ITI occurs at sample S7, where the highest proportion of Group 4 specimens and the lowest proportion of Group 1 specimens coincide, such that these two factors act together to reduce the ITI score for this sample. Nonetheless, although lower than for other samples, the ITI score for sample site S7 remains high, in the community unchanged category.

  Thus, overall, ITI supports the findings of the other univariate analyses; no organic pollution appears to be affecting the infauna in the survey area which, it is submitted, suggests the absence of environmental stress, prior to and at the time of the survey.

Figure 56.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Univariate analysis; biological indices generated form survey data.
See Table 13. Note purple bars show control site data.



	S1	S2	S3	S4	S5	S6	S7	SC1
Numbers/sample	376	422	320	501	447	405	312	281

	S1	S2	S3	S4	S5	S6	S7	SC1
Species/sample	38	29	29	25	29	37	41	22

	S1	S2	S3	S4	S5	S6	S7	SC1
Magalefs Index	6.24	4.63	4.85	3.86	4.59	6.00	6.97	3.72

	S1	S2	S3	S4	S5	S6	S7	SC1
Shannon Index	1.98	1.73	1.68	1.39	1.82	1.84	2.67	1.77

	S1	S2	S3	S4	S5	S6	S7	SC1
Pielou's Index	0.54	0.51	0.50	0.43	0.54	0.51	0.72	0.57

	S1	S2	S3	S4	S5	S6	S7	SC1
IT Index	76.97	78.06	79.29	79.46	77.95	79.03	73.00	77.01

2.10.3. Benthic survey results; multivariate analysis.

- Results; Bray Curtis similarity plot.
  The Bray Curtis similarity plot, generated by PRIMER v5 for the raw infaunal data collected at Shot Head in August 2009 is shown in Figure 57. This takes the form of a cluster plot, where the clustering becomes closer between sample sites as their similarity increases. The plot shows high dissimilarity between sample site S7 and a cluster of all other sites surveyed, at a similarity level of just 26.10%. The main cluster then breaks further in terms of similarity, at 58.00%, between control site SC1 and all remaining sites. These then break to form two smaller clusters at 60.80% similar, which links sites S4 and S1 in one cluster at 61.2% similar and S2, S3, S5 and S6 at 65.5% similar. The final clustering of sites S2 and S6 indicates that these two show the greatest similarity in infaunal characteristics of all the sites , at 81.4% similar.

  The most significant finding of the Bray Curtis result is the stark difference in infaunal population characteristics between site S7 and all other sites. This was alluded to in Section 2.10.2, and Tables 10, 11 and 12, which also clearly demonstrated a completely different infaunal composition at S7 relative to all other sites.

- Results; MDS ordination plot.
  Results in this case are shown in the 2-dimensional ordination plot in Figure 58. Again the clustering of all sites other than S7 and the distance between this cluster and the position of site S7 in the ordination confirm the findings of the Bray Curtis plot and the raw data analyses given in Section 2.10.2. The overlapping of all the data points barring S7 is just an indication of the closeness of their similarity, relative to the distance of their dissimilarity to S7

  The minimum stress level of 0.01, which occurred 20 times in the 20 iterations carried out (MDS ordination is an iterative process) suggests that the ordination generated is reliable, with no prospect at all of a misleading interpretation in the plot.

Figure 57.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Multivariate Analysis; Bray Curtis similarity plot of infaunal species.

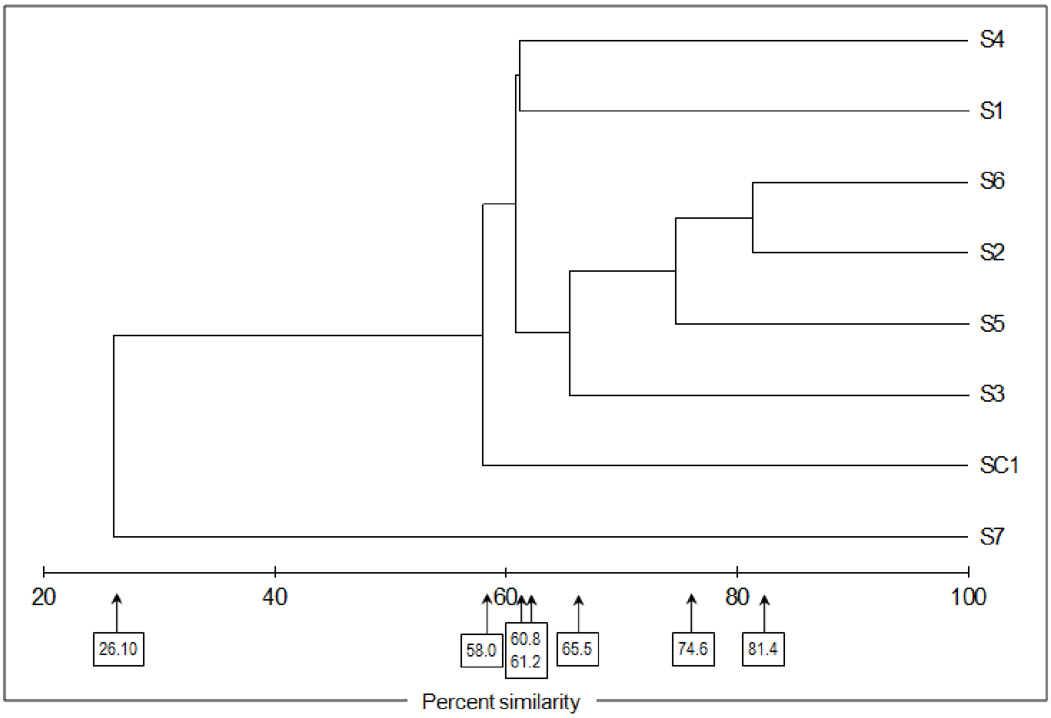
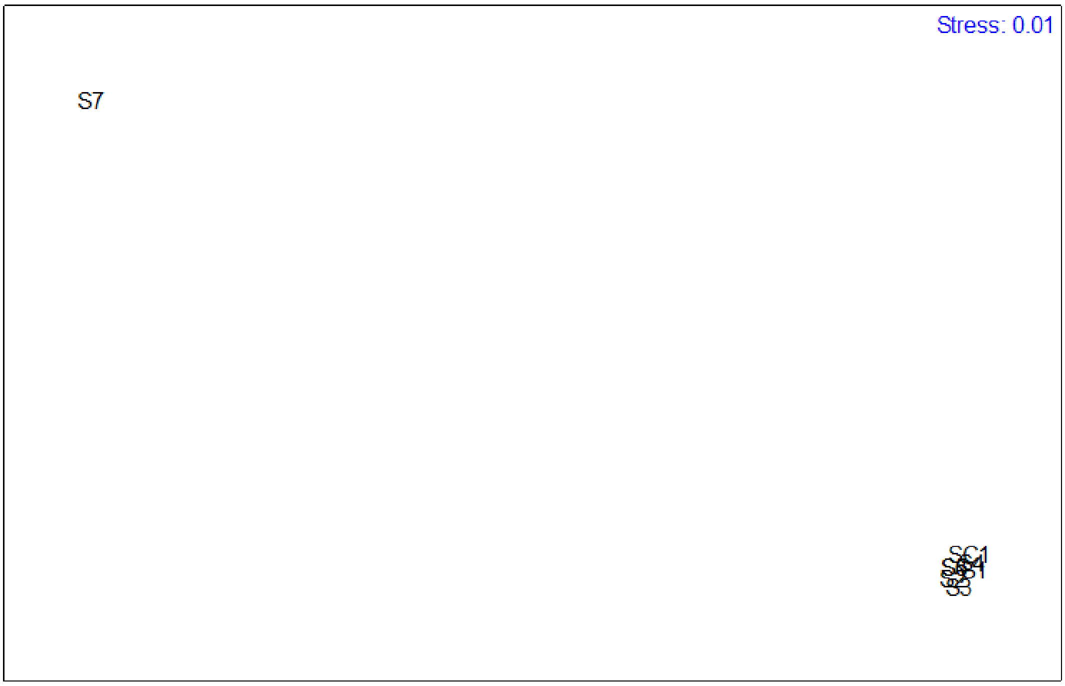


Figure 58.
EIS for a salmon farm site at Shot Head.
Shot Head benthic survey 5th August 2009.
Multivariate Analysis; MDS ordination plot of infaunal species.



2.11. Benthic survey results; discussion.

The results of all aspects of both the physico-chemical and the infaunal analyses carried out at the Shot Head are mutually supportive of a number of conclusions that can be drawn from the study.

Particulate sand analysis points to fairly homogeneous sediments which could be described as a mix of very coarse to fine sands and shell fragments with varying amounts of gravel and silt. The two sample sites that varied the most from this average picture were those at S7, to the south of the survey area, which showed a far higher gravel content (69% >2mm particular diameter) and correspondingly less sand and silt and the control site, SC1, 546m WSW of the proposed seabed area centre point, which showed a far higher silt content (52% <62µ particle diameter) and correspondingly less sand and gravel.

These differences in PSA at sites S7 and SC1 relative to the mean situation were reflected in the lowest redox and highest organic carbon values at being recorded SC1 (as might be expected in finer sediments) whilst the opposite was the case at S7, in the coarsest sediments found, where less humic material, larger void space and consequent higher water and oxygen permeability were likely to be factors.

This range of benthic physico-chemical features were also reflected in the relative composition of the infauna, site to site. All univariate analyses, including ITI were mutually supportive of an unstressed, unpolluted local environment. This was reflected in particular in the almost complete absence of ITI Trophic Group 4 species, resulting in very high ITI scores.

Further the extremes of sediment content >2mm found at site S7 was strongly reflected in a very different infaunal composition to that found at all other sites. This was also strongly indicated in the findings of the multivariate analyses executed, which demonstrate convincingly the differences between the infaunal composition at S7 relative to all other sites.

The reasons for the difference in sediments and infauna at S7 are difficult to establish although, despite the water depth in the area, this may be related to the influence of local shelter on highly localised wave climate patterns (the SW corner of the site is the most exposed; see Section 2.4). In all events, this is not an important consideration in the assessment the benthic environment in and around the proposed seabed area for this project. What is most important is that the benthic physico-chemical and infaunal study has established a firm baseline of an unstressed, unpolluted environment against which any future development in this sea area can be monitored.

2.12. ROV surveys.

Two surveys of the seabed area at the proposed Shot Head site were conducted, each using an underwater Remotely Operated Vehicle (ROV) equipped with an on-board video camera. The first was carried out by an officer of An Bord Iascaigh Mhara (BIM) on 14th September 2009; the second by Techworks Marine on 10th May 2010. Stills captured from the video recordings made are reproduced in Plates 1 to 30. The full videos are contained in the DVD accompanying this document. The details of each video transect are given in Table 14 and Figure 59.

Table 14.
EIS for a salmon farm site at Shot Head.
Shot Head ROV benthic surveys.
Details of the two surveys conducted at the proposed Shot Head site

Provider	Transect code	Date	Start time hh:mm:ss	Finish time hh:mm:ss	Duration mm:ss	A Start postion	B Mid position	C End Position
BIM	VTS1	14th September 2009	13:56:24	14:10:07	13:43	85130.77N 47714.58E	85213.47N 47699.34E	85162.21N 47605.90E
BIM	VTS2	14th September 2009	14:22:05	14:28:30	06:25	85154.05N 47627.14E	-	85109.41N 47627.14E
BIM	VTS3	14th September 2009	14:37:14	14:43:42	06:18	85162.21N 47605.90E	-	85306.09N 47663.85E
BIM	VTS4	14th September 2009	14:49:14	14:58:43	09:29	85317.54N 47650.23E	-	85210.07N 47580.33E
Techworks	N-C	10th May 2010	14:57:37	15:04:41	07:04	Approx middle of north side of site to centre point		
Techworks	C-S	10th May 2010	15:27:50	15:44:39	16:49	Approx site centre to middle of south side of site.		
Techworks	S-C	10th May 2010	15:46:33	15:49:47	03:14	Approx middle of south side of site to centre point		
Techworks	E-W	10th May 2010	16:12:47	16:24:01	11:14	Approx middle of east side of site to middle of west side of site		

As Plates 1-30 indicate, both ROV surveys show identical conditions and fauna, as might be expected. The seabed in the area surveyed is homogeneous, comprising a muddy, pitted, irregular surface, covering a sandy to gravelly subsurface. Rock was only encountered, in fragmented outcrops around the centre of the site area, which appears to coincide with the findings of the benthic survey (see Section 2.8.1 and Table 8) and data provided by the Infomar shaded relief bathymetry map shown in Figure 20.

Again as might be expected, the ROV records show that the rock fauna differed from that in the soft sediment areas. Both videos also show some particulate matter floating above the seabed. This does not appear to be an artefact resulting from the passage of the ROV's. Visible epifauna / infauna is neither dense nor in great variety. Undoubtedly the dominant species throughout the area are brittle stars, as indicated by the results of the benthic sampling survey in Section 2.10; the arms of *Amphiura filiformis* can be seen protruding from the sediment surface in many of the plates.

Whilst relatively sparsely distributed, the other most common species in the seabed area in both surveys were the seven-armed starfish *Luidia ciliaris* and *Nephrops norwegicus*. *Nephrops norwegicus* is a commercially exploited resource along the western Irish coastline but the number of burrow complexes indicated in the survey area by the ROV records would appear to be relatively low from the point of view of exploitation [25, 26]. Several specimens of the burrowing crab *Corystes cassivelaunus* were encountered in the surveys. A single specimen of the common prawn, *Palaemon serratus* was also seen. There has been a seasonal pot fishery for this species in the site area over the years. This is a migratory species and, should the licence for the Shot Head site be granted, there is no reason why potting should not continue around the site area. A number of vents and burrows in the sediments indicated the presence of a variety of infaunal species below the surface, likely to be both bivalve molluscs and annelid worms. Tube-dwelling anemones, holothurians and other species identified in the benthic infaunal analysis in Section 2.10 were not encountered in the ROV surveys.

The presence of macroalgae in the area was only indicated by some loose fronds throughout the survey areas. None were seen on the central rocky outcrop. Like much of the rocky shoreline of Bantry Bay, the inshore rocky area to the north of the proposed site area is in known to support beds of *Laminaria* and other macroalgae.

The most common species encountered on the very limited rocky area in the survey were small sea anemones, possibly *Actinia sp*., the edible urchin, *Echinus esculentis*, a variety of unidentified branching hydroids and tunicates.

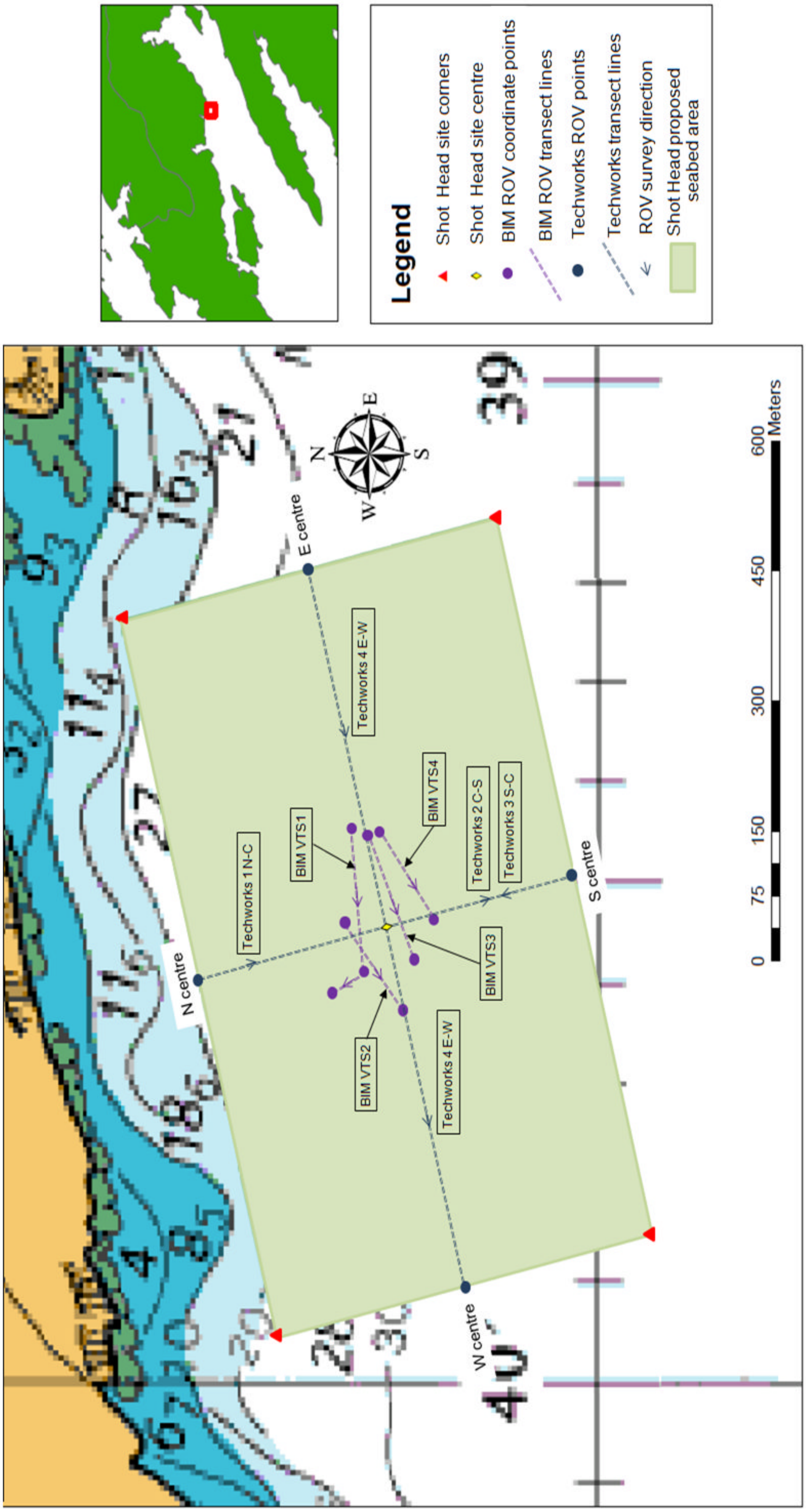
No listed or protected species were encountered in the survey. The presence of the tunicate *Phallusia mammillata* was noted. The known Irish distribution of this species in limited to inner Bantry Bay and very few other sites in Ireland[27]. However, it is not a listed species.

[25] Campbell, N., Allan, L., Weetman, A., and Dobby, H. 2009. Investigating the link between *Nephrops norvegicus* burrow density and sediment composition in Scottish waters. ICES Journal of Marine Science **66:** 2052–2059.

[26] Tully, O., and Hillis, J. P. 1995. Causes and spatial scales of variability in population structure of *Nephrops norvegicus* (L.) in the Irish Sea. Fisheries Research, **21**: 321–347.

[27] Hayward, P.J.; Ryland, J.S. (Ed.) (1990). The marine fauna of the British Isles and North-West Europe: 1. Introduction and protozoans to arthropods. Clarendon Press: Oxford, UK. ISBN 0-19-857356-1. 627 pp.

Figure 59.
EIS for a salmon farm site at Shot Head.
Shot Head ROV benthic surveys.
Details of ROV transects at the proposed Shot Head site.



Plates 1 and 2.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
BIM ROV survey 14th September 2009; Transect VST1; east to west; north of site long axis.

Plate 1. Seven-arm starfish, *Luidia ciliaris*.

Plate 2. Soft muddy sand with the rays (arms) of the ophiuroid *Amphiura filiformis* protruding from the sediments.

Plates 3 and 4.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
BIM ROV survey 14th September 2009; Transect VST1; east to west; north of site long axis.

Plate 3. *Nephrops norwegicus*, the Dublin Bay prawn.

Plate 4. Another shot of the arms (rays) of the brittlestar *Amphiura filiformis* protruding from the sediments.

Plates 5 and 6.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
BIM ROV survey 14th September 2009; Transect VST2; east to west; north of site long a

Plate 5. Specimens of the brittlestar *Ophiura ophiura*.

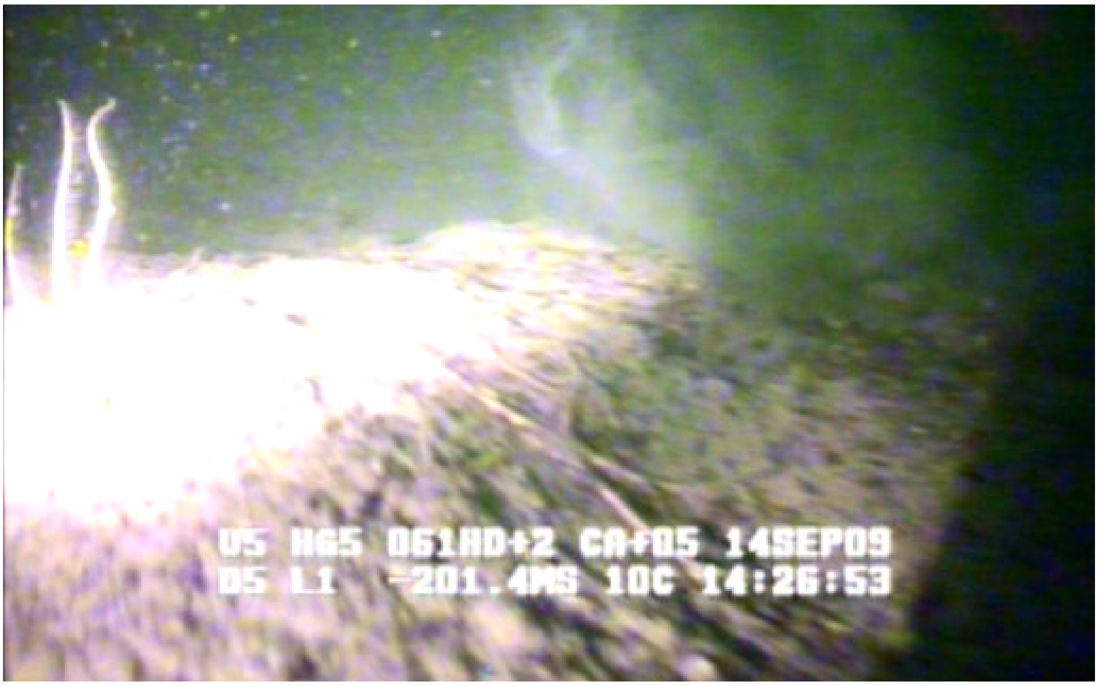


Plate 6. Another view of specimens if the brittlestar *Ophiura ophiura* in the foreground, with the arms (rays) of *Amphiura filiformis* to back left of frame.

Plates 7 and 8.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
BIM ROV survey 14th September 2009; Transect VST3; east to west; south of site long axis.

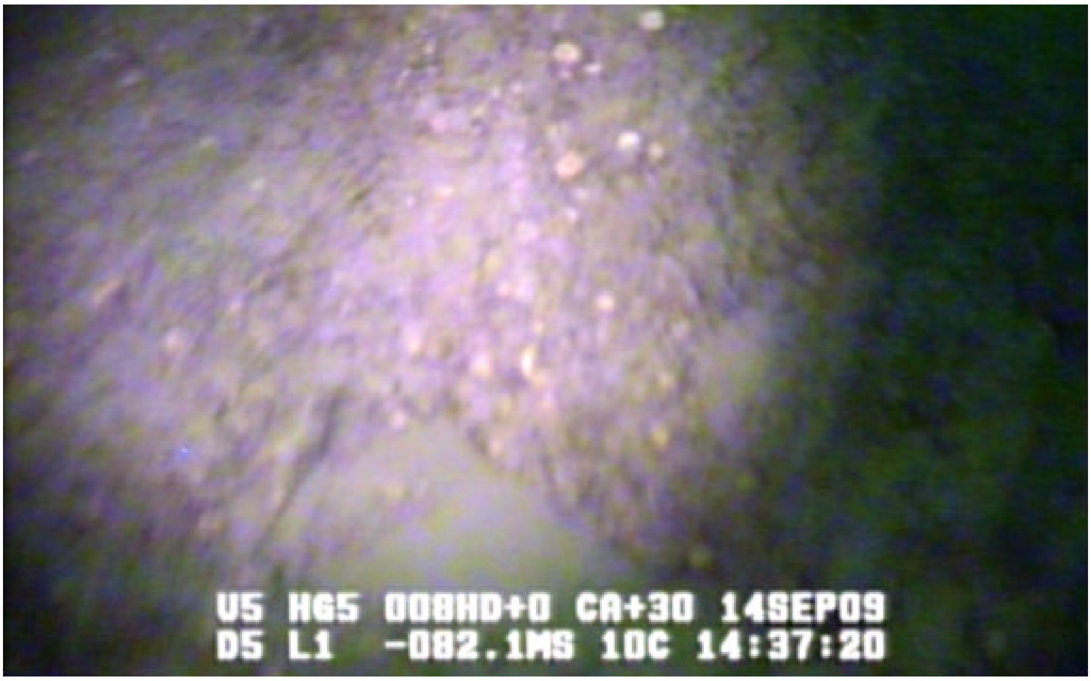


Plate 7. Rocky patch with specimens of unidentified sea anenomes.

Plate 8. Continuation of rocky patch with the edible urchins, *Echinus esculentis*.

Plates 9 and 10.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
BIM ROV survey 14th September 2009; Transect VST4; east to west; south of site long axis.

Plate 9. *Nephrops norwegicus* defending burrow.

Plate 10. The seven-armed starfish, *Luidia ciliaris*.

Plates 11 and 12.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
Techworks ROV survey 10th May 2010; Transect 1; Northern site limit to site centre.

Plate 11. *Nephrops norwegicus*, defending burrow.

Plate 12. Common prawn, *Palaemon serratus*. *Amphiura filiformis* in background.

Plates 13 and 14.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
Techworks ROV survey 10th May 2010; Transect 1; Northern site limit to site centre

Plate 13. The ophiuroid echinoderm (brittle star) *Ophiura ophiura*. The arms of many specimens of the brittle star, *Amphiura filiformis*, can be seen protruding from the sand around it. Burrows, probably of bivalves or annelids in background.

Plate 14. Rocky outcrop; small unidentifiable sea anenome to right of frame.

Plates 15 and 16.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
Techworks ROV survey 10th May 2010; Transect 1; Northern site limit to site centre.

Plate 15. Continuation of rocky outcrop seen in Plate 5; encrustation of rock includes unidentifiable branched hydroids and sea anenomes.

Plate 16. Loose kelp fronds (*Laminaria sp.*) with a specimen of the edible urchin, *Echinus esculentis*.

Plates 17 and 18.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
Techworks ROV survey 10th May 2010; Transect 2; site centre to southern site limit

Plate 17. Beginning of Transect 2; two specimens of tunicates, not positively identified. The one to the left is an Ascidean, that the the right possibly *Phallusia mammillata*. Behind them is a branched hydroid

Plate 18. Muddy sand with some small burrows and a specimen of the spiny starfish, *Marthasterias glacialis*.

Plates 19 and 20.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
Techworks ROV survey 10th May 2010; Transect 2; site centre to southern site limit.

Plate 19. Common shore crab, on muddy sand, *Carcinus maenas*.

Plate 20. Another specimen of the common shore crab, *Carcinus maenas*.

Plates 21 and 22.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
Techworks ROV survey 10th May 2010; Transect 2; site centre to southern site limit.

Plate 21. *Nephrops norwegicus, in entrance of* burrow.

Plate 22. The opiuroid echinoderm (brittle star) *Ophiura ophiura*.

Plates 23 and 24.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
Techworks ROV survey 10th May 2010; Transect 2; site centre to southern site limit.

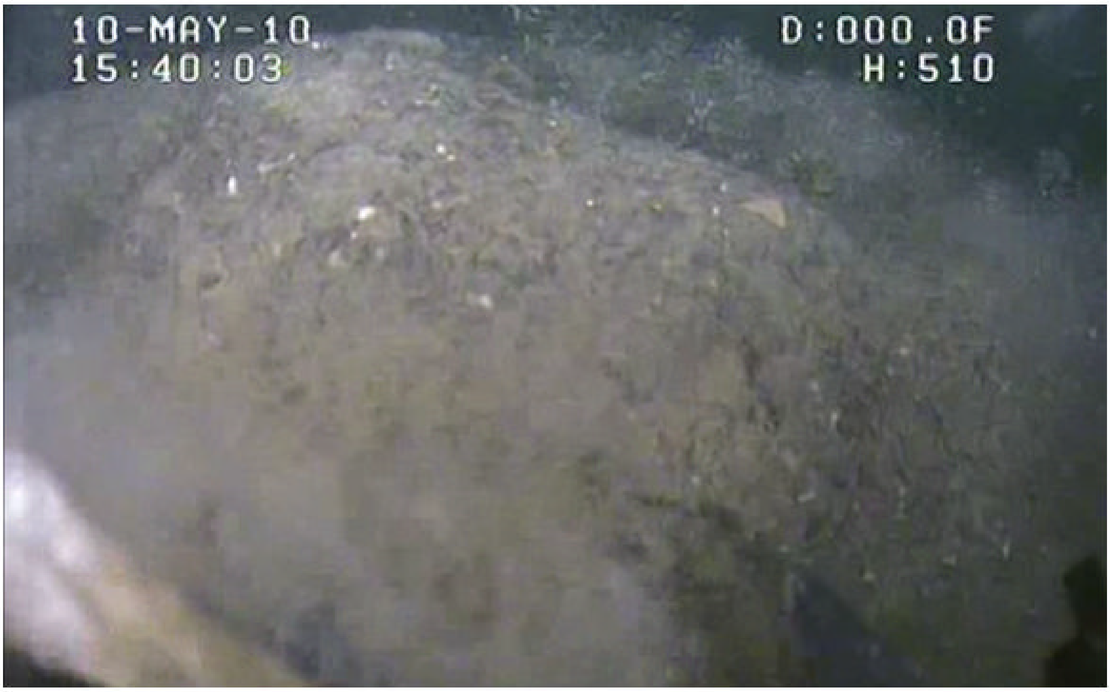


Plate 23. Showing seabed with pitted surface and silt / mud over gravel and shell.

Plate 24. The opiuroid echinoderm (brittle star) *Ophiura ophiura*.

Plates 25 and 26.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
Techworks ROV survey 10th May 2010; Transect 4; east to west of site.

Plate 25. The burrowing crab *Corystes cassivelaunus*.

Plate 26 The seven-armed starfish, *Luidia ciliaris*.

Plates 27 and 28.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
Techworks ROV survey 10th May 2010; Transect 4; east to west of site.

Plate 27.   The burrowing crab *Corystes cassivelaunus*.

Plare 28.   The seven-armed starfish, *Luidia ciliaris*.

Plates 29 and 30.
EIS for a salmon farm site at Shot Head.
ROV benthic surveys.
Techworks ROV survey 10th May 2010; Transect 4; east to west of site.

Plate 29 The seven-armed starfish, *Luidia ciliaris*.

Plate 30. The common hermit crab *Eupagurus bernhardus*.

Section 3.
Production processes and effects.

3.1. The proposed farming cycle.

The proposed salmon farm site at Shot Head is designed to hold an maximum standing biomass of 2,800 tonnes at a peak stocking density of 10kg/m^3 of salmon. Peak biomass will occur in February to March of Year 2 in each production cycle; see Table 15 and in Figure 60. The stock used will be S0 smolt stock (smolt ready for transfer from freshwater to seawater in late autumn in the year of their hatch). Smolt will be transferred to the site by well boat[28], at a mean weight of 75g in October to November every two years, to complete their entire grow out cycle of 22 months to harvest, at the site. Mean harvest round weight is expected to be in the range of 4.5 to 5.6kg.

Table 15 illustrates the anticipated first production cycle for the Shot Head site, commencing October / November 2011 at the earliest, with the transfer of a maximum of 836,000 smolt. This is the number of smolt required to enable the projected total harvest weight of 3,500 tonnes to be achieved, at the projected harvest mean fish weight, with a projected mortality allowance of 19.5% and assuming the growth rate model shown in Figure 60 (based on MHI standard growth data). Following transfer, the smolt will be allowed to grow out to an approximate mean weight of 2.5kg in about month 13 to 14 post transfer, when they will be counted, graded and redistributed in preparation for harvest. Harvesting will commence in March of the second year of the cycle, approximately 17 months after smolt transfer to the site. The total harvest weight of some 3,500 tonnes of salmon will be completed by August (month 22), some six months later.

The site will then be fallowed for no less than two months, subject to the precise date of completion of harvesting. The site will then be restocked for the next cycle at the end of October or beginning of November, in the 25th month after the first transfer. Table 16 and Figure 60 illustrate the main production parameters for multiple production cycles at the Shot Head site.

Actual rather than projected mortality and growth rate will dictate the smolt numbers required to achieve the harvest target of 3,500 tonnes per 24-month cycle. However, the mortality allowance of 19.5% is regarded as generous rather than conservative and the projected harvest mean weight of 4.5kg to 5.6kg is already being achieved on MHI farms. Nonetheless, it is advised that a peak smolt transfer number of 850,000 is sought in the licence application.

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28 The well boat, MV Grip Transporter is under long-term lease to the company for the purposes of smolt transfer, counting, grading and harvesting; see specification in Section 3.3.4.

Table 15.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Projected base grow-out model for proposed Shot Head site.

Notes
1. Licence application is for a proposed maximum standing biomassof 2,800 tonnes per 24-month cycle.
2. Proposed transfer biomass is 62.7 tonnes (smolt) and estimated maximum harvest is 3,500 tonnes per 24-month cycle. Thus biogain per cycle = 3,436.9 tonnes.
3. See summary boxes under spreadsheet for proposed production overview.
4. Stocking density data given assumes Shot Head mean cage volume is 20,000m^3; thus maximum total cage volume = 14 x 20,000 = 280,000m^3.

Key
- Data used for calculation of discharge budget.
- Stocking density data; assumes that all cages will be used throughout the cycle. However in practice cage numbers increase with total standing stock.
- **2,800** Cycle maximum standing biomass (2,800 tonnes) will be reached in February to March in Year 2.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Year	Month	Months growth	Fish number		Mortality		Mean weight gms		Total Biomass T		Mean SD @ cage volume	Biogain/ month tonnes	Harvest			FCR	Feed used T / month
			Start month	End month	% per month	Number / month	Start month	End month	Start month	End month			Number	Mean wt kg	Harvest tonnes		
1	Nov	1	835,884	814,987	2.50	20,897	75	101	62.7	82.3	0.3	19.6	0	0	0	0.95	18.6
1	Dec	2	814,987	802,762	1.50	12,225	101	141	82.3	113.2	0.4	30.9	0	0	0	0.95	29.3
1	Jan	3	802,762	796,340	0.80	6,422	141	198	113.2	157.7	0.6	44.5	0	0	0	1.00	44.5
1	Feb	4	796,340	792,358	0.50	3,982	198	275	157.7	217.9	0.8	60.2	0	0	0	1.10	66.2
1	Mar	5	792,358	788,397	0.50	3,962	275	375	217.9	295.6	1.1	77.8	0	0	0	1.20	93.3
1	Apr	6	788,397	784,455	0.50	3942	375	505	295.6	396.1	1.4	100.5	0	0	0	1.20	120.6
1	May	7	784,455	777,394	0.90	7060	505	670	396.1	520.9	1.9	124.7	0	0	0	1.23	152.8
1	Jun	8	777,394	768,066	1.20	9,329	670	880	520.9	675.9	2.4	155.0	0	0	0	1.25	193.8
1	Jul	9	768,066	756,545	1.50	11,521	880	1,130	675.9	854.9	3.1	179.0	0	0	0	1.27	227.3
1	Aug	10	756,545	739,144	2.30	17,401	1,130	1,417	854.9	1,047.4	3.7	192.5	0	0	0	1.27	244.4
1	Sep	11	739,144	725,840	1.80	13,305	1,417	1,745	1,047.4	1,266.6	4.5	219.2	0	0	0	1.27	278.4
1	Oct	12	725,840	721,485	0.60	4,355	1,745	2,120	1,266.6	1,529.5	5.5	263.0	0	0	0	1.27	334.0
2	Nov	13	721,485	712,827	1.20	8,658	2,120	2,550	1,529.5	1,817.7	6.5	288.2	0	0	0	1.27	366.0
2	Dec	14	712,827	707,124	0.80	5,703	2,550	3,025	1,817.7	2,139.1	7.6	321.3	0	0	0	1.27	408.1
2	Jan	15	707,124	702,174	0.70	4,950	3,025	3,540	2,139.1	2,485.7	8.9	346.6	0	0	0	1.27	440.2
2	Feb	16	702,174	693,748	1.20	8,426	3,540	4,036	2,485.7	**2,800**	10.0	314.3	0	0	0	1.27	399.1
2	Mar	17	693,748	600,423	1.20	8,325	4,036	4,534	**2,800**	2,722.3	9.7	304.9	85,000	4.500	382.50	1.27	387.2
2	Apr	18	600,423	475,620	0.80	4,803	4,534	4,975	2,722.3	2,366.2	8.5	207.9	120,000	4.700	564.00	1.27	264.0
2	May	19	475,620	336,815	0.80	3,805	4,975	5,248	2,366.2	1,767.6	6.3	110.1	135,000	5.250	708.75	1.27	139.9
2	Jun	20	336,815	229,794	0.60	2,021	5,248	5,420	1,767.6	1,245.5	4.4	44.9	105,000	5.400	567.00	1.27	57.0
2	Jul	21	229,794	118,645	0.50	1,149	5,420	5,544	1,245.5	657.8	2.3	28.3	110,000	5.600	616.00	1.27	35.9
2	Aug	22	118,645	0	0.40	475	5,544	5,600	657.8	0.0	0.0	4.0	118,170	5.600	661.75	1.27	5.1
2	Sep	23	Harvest completed. Site fallow until next smolt input.														
2	Oct	24															
Totals						162,714						3,437.3	**673,170**	**5.20**	**3,500.00**		4,305.8

Fish numbers / percent summary		
Fish transferred to site Oct / Nov	835,884	%
Total site mortality allowance and %	162,714	19.5
Total fish number harvested	673,170	

Harvest / biogain summary tonnes	
Total weight fish harvested tonnes	3,500.0
Transfersmolt weight in, tonnes	62.7
Total cycle biogain tonnes	3,437.3

Feeding and feed conversion rate summary	
Total feed fed per production cycle tonnes	4,305.8
Biogain	3,437.3
Thus overall feed conversion rate	1.25

Table 16.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Projected multi-generation grow-out model for proposed Shot Head site.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Year	Month	Months growth	Fish number		Mortality		Mean weight gms		Total Biomass T		Mean SD @ cage volume 28,000m³	Biogain/ month tonnes	Harvest			FCR	Feed used T / month
			Start month	End month	% per month	Number / month	Start month	End month	Start month	End month			Number	Mean wt kg	Harvest tonnes		
1	Nov	1	835,884	814,987	2.50	20,897	75	101	62.7	82.3	0.3	19.6	0	0	0	0.95	18.6
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1	Jan	3	802,762	796,340	0.80	6,422	141	198	113.2	157.7	0.6	44.5	0	0	0	1.00	44.5
1	Feb	4	796,340	792,358	0.50	3,982	198	275	157.7	217.9	0.8	60.2	0	0	0	1.10	66.2
1	Mar	5	792,358	788,397	0.50	3,962	275	375	217.9	295.6	1.1	77.8	0	0	0	1.20	93.3
1	Apr	6	788,397	784,455	0.50	3942	375	505	295.6	396.1	1.4	100.5	0	0	0	1.20	120.6
1	May	7	784,455	777,394	0.90	7060	505	670	396.1	520.9	1.9	124.7	0	0	0	1.23	152.8
1	Jun	8	777,394	768,066	1.20	9,329	670	880	520.9	675.9	2.4	155.0	0	0	0	1.25	193.8
1	Jul	9	768,066	756,545	1.50	11,521	880	1,130	675.9	854.9	3.1	179.0	0	0	0	1.27	227.3
1	Aug	10	756,545	739,144	2.30	17,401	1,130	1,417	854.9	1,047.4	3.7	192.5	0	0	0	1.27	244.4
1	Sep	11	739,144	725,840	1.80	13,305	1,417	1,745	1,047.4	1,266.6	4.5	219.2	0	0	0	1.27	278.4
1	Oct	12	725,840	721,485	0.60	4,355	1,745	2,120	1,266.6	1,529.5	5.5	263.0	0	0	0	1.27	334.0
2	Nov	13	721,485	712,827	1.20	8,658	2,120	2,550	1,529.5	1,817.7	6.5	288.2	0	0	0	1.27	366.0
2	Dec	14	712,827	707,124	0.80	5,703	2,550	3,025	1,817.7	2,139.1	7.6	321.3	0	0	0	1.27	408.1
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2	Sep	23	Harvest completed. Site fallow until next smolt input.														
2	Oct	24															
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2	Dec	2	814,987	802,762	1.50	12,225	101	141	82.3	113.2	0.4	30.9	0	0	0	0.95	29.3
3	Jan	3	802,762	796,340	0.80	6,422	141	198	113.2	157.7	0.6	44.5	0	0	0	1.00	44.5
3	Feb	4	796,340	792,358	0.50	3,982	198	275	157.7	217.9	0.8	60.2	0	0	0	1.10	66.2
3	Mar	5	792,358	788,397	0.50	3,962	275	375	217.9	295.6	1.1	77.8	0	0	0	1.20	93.3
3	Apr	6	788,397	784,455	0.50	3942	375	505	295.6	396.1	1.4	100.5	0	0	0	1.20	120.6
3	May	7	784,455	777,394	0.90	7060	505	670	396.1	520.9	1.9	124.7	0	0	0	1.23	152.8
3	Jun	8	777,394	768,066	1.20	9,329	670	880	520.9	675.9	2.4	155.0	0	0	0	1.25	193.8
3	Jul	9	768,066	756,545	1.50	11,521	880	1,130	675.9	854.9	3.1	179.0	0	0	0	1.27	227.3
3	Aug	10	756,545	739,144	2.30	17,401	1,130	1,417	854.9	1,047.4	3.7	192.5	0	0	0	1.27	244.4
3	Sep	11	739,144	725,840	1.80	13,305	1,417	1,745	1,047.4	1,266.6	4.5	219.2	0	0	0	1.27	278.4
3	Oct	12	725,840	721,485	0.60	4,355	1,745	2,120	1,266.6	1,529.5	5.5	263.0	0	0	0	1.27	334.0
3	Nov	13	721,485	712,827	1.20	8,658	2,120	2,550	1,529.5	1,817.7	6.5	288.2	0	0	0	1.27	366.0
3	Dec	14	712,827	707,124	0.80	5,703	2,550	3,025	1,817.7	2,139.1	7.6	321.3	0	0	0	1.27	408.1
4	Jan	15	707,124	702,174	0.70	4,950	3,025	3,540	2,139.1	2,485.7	8.9	346.6	0	0	0	1.27	440.2
4	Feb	16	702,174	693,748	1.20	8,426	3,540	4,036	2,485.7	2,800	10.0	314.3	0	0	0	1.27	399.1
4	Mar	17	693,748	600,423	1.20	8,325	4,036	4,534	2,800	2,722.3	9.7	304.9	85,000	4.500	382.50	1.27	387.2
4	Apr	18	600,423	475,620	0.80	4,803	4,534	4,975	2,722.3	2,366.2	8.5	207.9	120,000	4.700	564.00	1.27	264.0
4	May	19	475,620	336,815	0.80	3,805	4,975	5,248	2,366.2	1,767.6	6.3	110.1	135,000	5.250	708.75	1.27	139.9
4	Jun	20	336,815	229,794	0.60	2,021	5,248	5,420	1,767.6	1,245.5	4.4	44.9	105,000	5.400	567.00	1.27	57.0
4	Jul	21	229,794	118,645	0.50	1,149	5,420	5,544	1,245.5	657.8	2.3	28.3	110,000	5.600	616.00	1.27	35.9
4	Aug	22	118,645	0	0.40	475	5,544	5,600	657.8	0.0	0.0	4.0	118,170	5.600	661.75	1.27	5.1
4	Sep	23	Harvest completed. Site fallow until next smolt input.														
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4	Nov	1	835,884	814,987	2.50	20,897	75	101	62.7	82.3	0.3	19.6	0	0	0	0.95	18.6
4	Dec	2	814,987	802,762	1.50	12,225	101	141	82.3	113.2	0.4	30.9	0	0	0	0.95	29.3
5	Jan	3	802,762	796,340	0.80	6,422	141	198	113.2	157.7	0.6	44.5	0	0	0	1.00	44.5
5	Feb	4	796,340	792,358	0.50	3,982	198	275	157.7	217.9	0.8	60.2	0	0	0	1.10	66.2
5	Mar	5	792,358	788,397	0.50	3,962	275	375	217.9	295.6	1.1	77.8	0	0	0	1.20	93.3
5	Apr	6	788,397	784,455	0.50	3942	375	505	295.6	396.1	1.4	100.5	0	0	0	1.20	120.6
5	May	7	784,455	777,394	0.90	7060	505	670	396.1	520.9	1.9	124.7	0	0	0	1.23	152.8
5	Jun	8	777,394	768,066	1.20	9,329	670	880	520.9	675.9	2.4	155.0	0	0	0	1.25	193.8
5	Jul	9	768,066	756,545	1.50	11,521	880	1,130	675.9	854.9	3.1	179.0	0	0	0	1.27	227.3
5	Aug	10	756,545	739,144	2.30	17,401	1,130	1,417	854.9	1,047.4	3.7	192.5	0	0	0	1.27	244.4
5	Sep	11	739,144	725,840	1.80	13,305	1,417	1,745	1,047.4	1,266.6	4.5	219.2	0	0	0	1.27	278.4
5	Oct	12	725,840	721,485	0.60	4,355	1,745	2,120	1,266.6	1,529.5	5.5	263.0	0	0	0	1.27	334.0
5	Nov	13	721,485	712,827	1.20	8,658	2,120	2,550	1,529.5	1,817.7	6.5	288.2	0	0	0	1.27	366.0
5	Dec	14	712,827	707,124	0.80	5,703	2,550	3,025	1,817.7	2,139.1	7.6	321.3	0	0	0	1.27	408.1
6	Jan	15	707,124	702,174	0.70	4,950	3,025	3,540	2,139.1	2,485.7	8.9	346.6	0	0	0	1.27	440.2
6	Feb	16	702,174	693,748	1.20	8,426	3,540	4,036	2,485.7	2,800	10.0	314.3	0	0	0	1.27	399.1
6	Mar	17	693,748	600,423	1.20	8,325	4,036	4,534	2,800	2,722.3	9.7	304.9	85,000	4.500	382.50	1.27	387.2
6	Apr	18	600,423	475,620	0.80	4,803	4,534	4,975	2,722.3	2,366.2	8.5	207.9	120,000	4.700	564.00	1.27	264.0
6	May	19	475,620	336,815	0.80	3,805	4,975	5,248	2,366.2	1,767.6	6.3	110.1	135,000	5.250	708.75	1.27	139.9
6	Jun	20	336,815	229,794	0.60	2,021	5,248	5,420	1,767.6	1,245.5	4.4	44.9	105,000	5.400	567.00	1.27	57.0
6	Jul	21	229,794	118,645	0.50	1,149	5,420	5,544	1,245.5	657.8	2.3	28.3	110,000	5.600	616.00	1.27	35.9
6	Aug	22	118,645	0	0.40	475	5,544	5,600	657.8	0.0	0.0	4.0	118,170	5.600	661.75	1.27	5.1
6	Sep	23	Harvest completed. Site fallow until next smolt input.														
6	Oct	24															

Tables 15 and 16 project a mean cycle Feed Conversion Rate (FCR) for stock held at the Shot Head site of 1.25:1. This means that a cycle average of 1.25kg of dry, proprietary salmon feed will be required to achieve each 1kg growth of salmon (as wet weight). This is readily achievable using modern salmon feeds and feed application technology. FCR is important because it is the most influential parameter in the growth of stock and in the discharge of organic wastes from salmon farm sites; see Section 4.

From the projections in Tables 15 and 16 it can be seen that, since the weight of the 836,000 smolt transferred to the system per cycle is 62.7 tonnes and the final harvest weight is 3,500 tonnes, the weight of fish produced (or total fish growth) on the site in each cycle will be 3,437.3 tonnes (= 3,500-62.7). At a mean Feed Conversion Rate for the cycle of 1.25:1, 4,305.8 tonnes (= 1.25 x 3,437.3) of organic salmon feed will be fed to the stock in each cycle.

Of all domesticated stock, salmon are by far the most efficient converters of feed into growth. The next most efficient are chickens, which convert dry rations at an FCR of 2.2:1, or 47% less efficiently than salmon. This is mainly a result of the additional energy required to maintain warm blooded terrestrial animals and to support them against gravity, relative to the requirements of fish, which are cold-blooded and require little support, being near-neutrally buoyant in an aquatic environment. Thus the farming of salmon requires less feed per unit of growth. As a result, salmon farming produces less waste than farming the equivalent weight of other types of domestic livestock. A further benefit is that the flesh yield of salmon is greater than that for terrestrial livestock, which all have a greater proportion of skeleton to flesh.

Tables 15 and 16 show that the intended maximum mean stocking density of fish at the Shot Head site 10kg/m^3. This is low by international salmon farming standards and one fifth of the peak stocking levels used in salmon farming in the past. This is in line with the high animal welfare principles and organic salmon farming standards to which MHI operate their organic farming units; see Section 1.2. This strategy offers benefits to fish health, survival, scale and fin integrity, growth rate and the evenness of fish weight mean distribution in the cage population. There will also be benefits in more diffuse deposition of settleable solids beneath cages, as a result of the reduction in stock biomass standing over each square metre of seabed, with lower stocking density.

Another consequence of the use of high organic welfare standards and low stocking densities is that, of necessity, cage volumes and seabed area requirements are greater than for more heavily stocked farms. However any disadvantages that may be construed from this fact is greatly outweighed by the advantages, to fish health and welfare, fish growth and the environment.

Figure 60.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Projected mean weight and total biomass growth rate and harvest; proposed Shot Head site only.

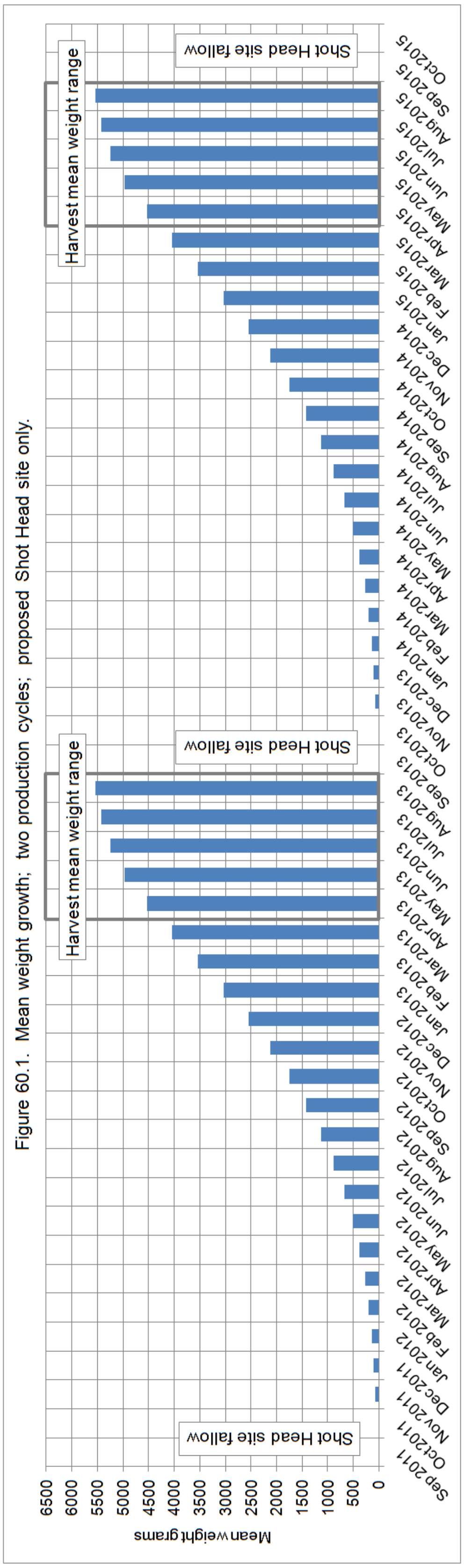


Figure 60.1. Mean weight growth; two production cycles; proposed Shot Head site only.

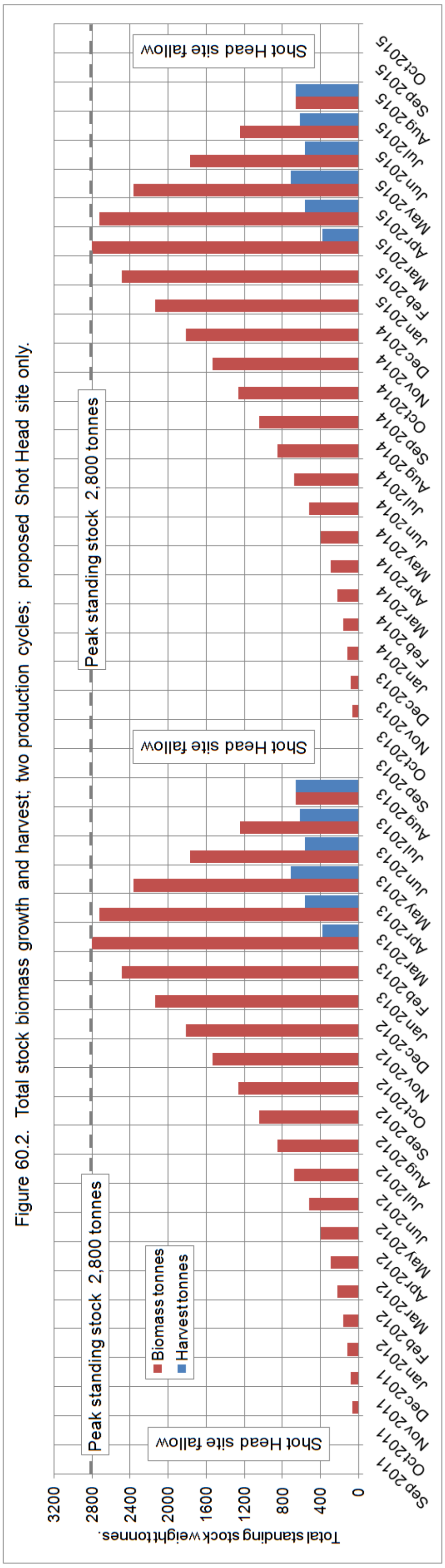


Figure 60.2. Total stock biomass growth and harvest; two production cycles; proposed Shot Head site only.

3.2. Production scenarios for Bantry Bay.

MHI now operates salmon farm sites under organic production standards in Clew Bay, Kenmare Bay and Bantry Bay. The company also produces "Global Gap®" accredited non-organic salmon in other bays in County Donegal. MHI's medium to long-term objectives for the development of its salmon farming operations are focussed on the adoption and advancement of current best practice. The company has always been an industry leader in this regard, as exemplified by its development of high welfare organic salmon farming. A further area for advancement will come through the optimisation of stocking, fallowing and site alternation strategies, as outlined below:-

3.2.1. Single bay site alternation.

It is now recognised that best welfare and environmental practices in salmon farming are aided by the establishment of sufficient farm sites, in a sufficient number of bays and loughs that multiple options for site alternation and fallowing are available, to suit circumstances. Rotation and fallowing are well-established agricultural practices that apply equally to farming in the sea. Fallowing brings two main benefits[29]:-

- The interruption of disease or infestation cycles with a consequent reduction animal health issues and veterinary intervention needs.

- The ability to vacate cages over a farm seabed area, to allow adequate time for the rejuvenation of the seabed, prior to the input of new stock.

Alternating site stocking, to include fallowing, requires at least two sites of similar size in each suitable bay. If the proposed Shot Head site is licensed, this is the strategy that MHI will use in Bantry Bay, in the first instance. Shot Head would undergo a 2-year production cycle, resulting in a 3,500 tonne harvest, by month 20 to 22. After this, the site will be fallowed for 2 to 4 months, before restocking for the next cycle, at the beginning of Year 3. If the Roancarrig site is stocked one year after Shot Head, this will result in a similar harvest one year after the Shot Head harvest. With ongoing alternation, MHI will be able to take an annual harvest of 3,500 tonnes, from the two sites. This strategy is illustrated in Figures 60.1 and 60.2, which show how the alternating cycles overlap, resulting in annual harvests. However, despite its advantages, site alternation has some disadvantages, as follows.

[29] Anon. 2000. Protocol for fallowing at offshore fin fish farms. Department for Agriculture, Marine and Food, Dublin, 2pp.

3.2.2. Synchronous Stocking and Whole Bay Rotation

Site alternation within one bay requires more than one generation of fish to be in the bay at any time. Equally, a bay cannot be completely fallow at any time. An alternative strategy, known as *Synchronous Stocking*, is more in line with Single Bay Management, an aspiration adopted in Ireland some years ago. A similar strategy is used in Scotland, where Area Management Agreements have been established. The strategy requires cooperation between producers, where there is more than one producer in a bay. There are two producers in Bantry Bay (see Section 2.1.4). Synchronous Stocking has three main objectives:-

- Fish of only one generation can be grown in one bay at any time.
- Producers share information on fish health status. Required veterinary treatments synchronised between producers if necessary.
- Stocking, harvesting and fallowing of all sites synchronised between producers, with the further option of *Whole Bay Rotation*, by which entire bays can be fallowed for extended periods, if needed.

To achieve single generation production in one bay, as well as annual harvesting, each producer must have a similar site capacity in at least one more bay. However, three or more rotating bays is a preferred option in that whole bay fallowing can then be rotated between all the bays in the group, whilst all other bays are used for production. This is illustrated in Figures 61.3 and 61.4 which show synchronised stocking and harvesting of two sites in one bay. Figure 62 shows the use of whole bay rotation and fallowing, with a group of four similar bays, such that each is left fallow for one year, once in every four inputs.

Note that, if a synchronous stocking strategy is adopted in any bay in which MHI operates and subject to agreement with other producers in the bay, single bays would be stocked with either S0 (autumn transfer) or S1 (spring transfer) smolt of one generation only. This is in line with Single Bay Management / Area Management practices and also enables synchronisation of transfers, harvesting and fallowing. MHI already uses both S0 and S1 smolts in its operations, albeit in separate bays. This has the advantage of improving the cost benefit of hatchery operations and extending the company's overall harvest window for similarly-sized fish (say 4.5 to 5.6 kg) from a minimum of six months to up to 12 months, such that product market availability can be continuous. MHI will use S0 smolt in the first instance in Bantry Bay.

Figure 61.
EIS for a salmon farm site at Shot Head.
Operating facilties.
Annual alternate site stocking versus biennial synchronous stocking.

Figure 61.1. One bay, two alternating sites; combined monthly standing stock, tonnes.

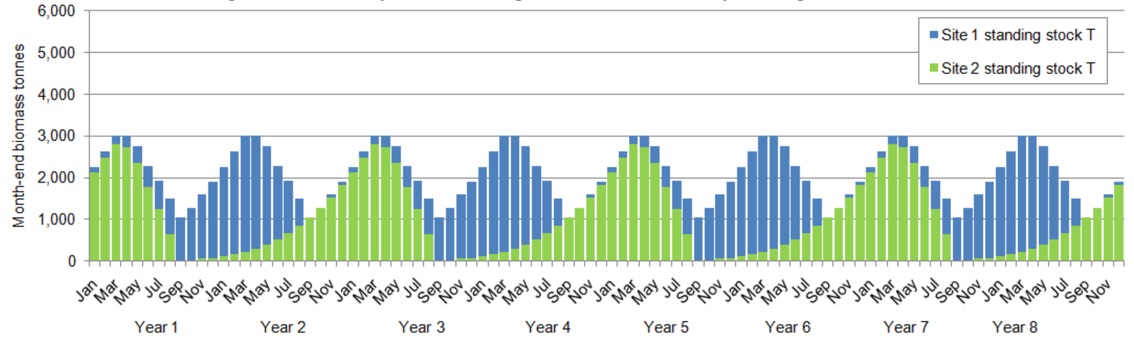


Figure 61.2 One bay, two alternating sites; results in combined annual harvest, tonnes.

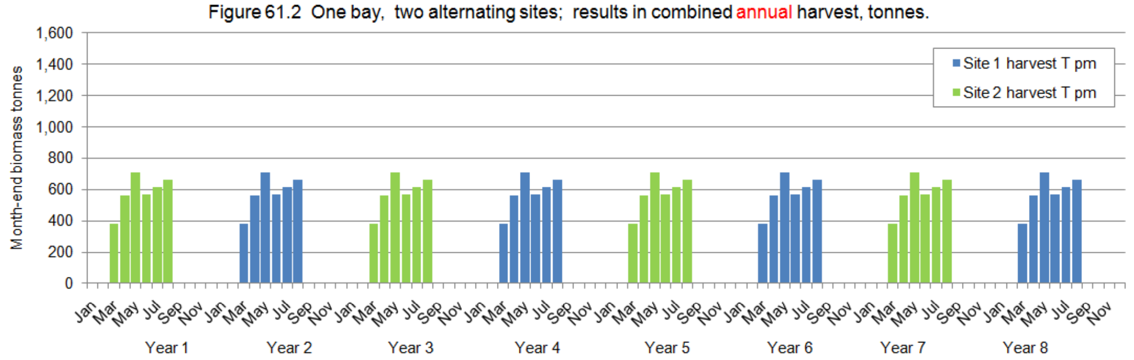


Figure 61.3. One bay, two synchronised sites; combined monthly standing stock, tonnes.

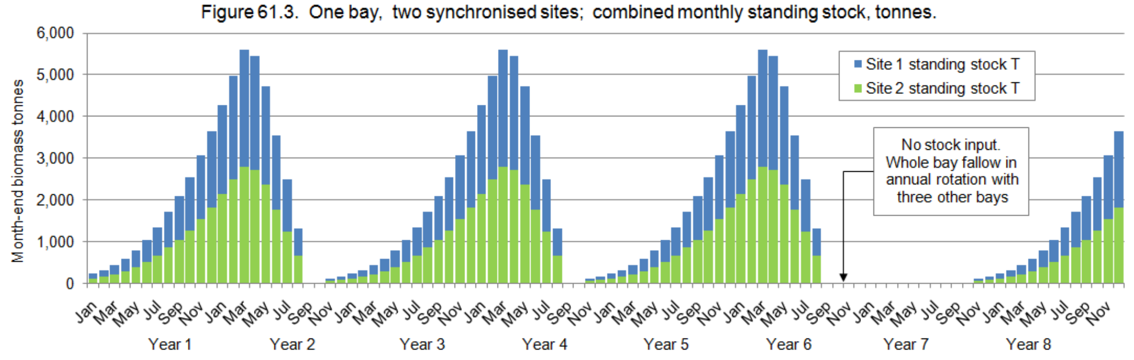


Figure 61.4. One bay, two synchronised sites, results in combined biennial harvest, tonnes.

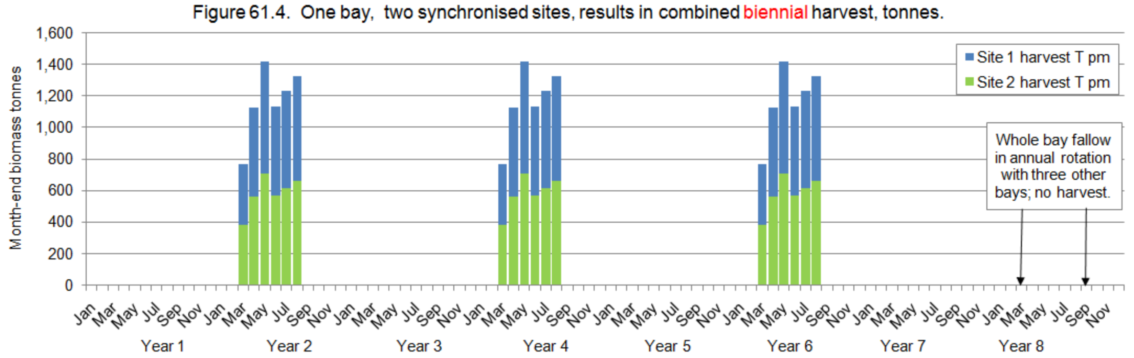


Figure 62.
EIS for a salmon farm site at Shot Head.
Operating facilties.
Synchronous site stocking and whole bay rotation; four-bay example.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bay 1	Cycle 1		Cycle 2		Cycle 3		Bay fallow	Cycle 4		Cycle 5		Cycle 6		Bay fallow
Bay 2	Bay fallow	Cycle 1		Cycle 2		Cycle 3		Bay fallow	Cycle 4		Cycle 5		Cycle 6	
Bay 3		Bay fallow	Cycle 1		Cycle 2		Cycle 3		Bay fallow	Cycle 4		Cycle 5		
Bay 4			Bay fallow	Cycle 1		Cycle 2		Cycle 3		Bay fallow	Cycle 4		Cycle 5	
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14

3.2.3. Single bay site alternation versus synchronous stocking.

Alternative bay management strategies are discussed at this juncture because the quantities of discharges entering the water column from the farming operation depends on the strategy selected. Synchronous stocking (Figures 56.3 and 56.4) offers a number of advantages over alternate stocking (Figures 56.1 and 56.2), namely:-

- Limited to single generation stocking per bay, which avoids any possibility of pathogen or parasite transfer between generations.
- End of cycle synchronous fallowing of all sites in the bay, to break pathogen and parasite infection cycles, is achievable.
- Subject to the availability of other bays, whole bay rotation and extended fallowing is simpler to achieve.
- If required, synchronous veterinary treatment is simpler to achieve.

However, as Figure 56.3 shows, standing stocks for synchronously stocked sites reach almost double that for alternately stocked sites. As expected that discharges would increase by a similar amount. It is the task of this EIS to investigate the impacts of likely worst-case scenarios of all aspects of the Shot Head proposal. Therefore, since synchronous stocking results in the greatest discharges, combined discharges resulting from the synchronous stocking of all salmon farm sites in Bantry Bay must be investigated; see Section 4.6.

3.3. Operating facilities

3.3.1. Site area

As outlined in Section 1.4 and shown in Figure 4, the overall seabed site area to be applied for at Shot Head measures 850m x 500m, giving an area of 42,500m^2, or 42.5 hectares, with the long axis running 257º / 77º to grid north. This overall site area is requested in order to fully accommodate the lengths of the moorings for anchoring the cage mooring grid, to accommodate both the cages and a feed barge and to allow sufficient room for the movement of the cage installation over new ground, within the site area, for improved fallowing, should the need arise.

It is again emphasised that the sea bed area proposed only has a notional boundary; it is not in any way a physical boundary and will not prevent ingress by other water users. It would be normal, for example, for inshore fishermen to pot around the moorings of fish farms and there have been occasions in the past when, in emergency situations, vessels have sought refuge and a mooring alongside fish farm cages.

3.3.2. Cages

It is understood that, under a recently introduced scheme, the final specifications for the cage system proposed for the Shot Head site will have to be submitted to the Engineering Section of the Aquaculture and Foreshore Management Division of the newly named Department of Agriculture Marine and Food for certification prior to installation. Thus precise specification is not a matter for this document. Design and certification of specifications will take full account of the ambient operating conditions for the installation, in particular currents and wave climate described herein. The general layout of components is set out in Figures 63 and 64. Their proposed orientation within the seabed area to be applied for is shown in Figure 4.

By way of general specification, each cage will have a surface floatation ring with a circumference of 128m (nominal diameter 41m), comprising three heavy duty polyethylene tubes. These will be supported within heavy duty polyethylene or steel base frames set at regular intervals around the floatation ring, upon which stanchions will be mounted to support the heavy duty handrail that runs around the cage; see Figures 63 and 64. Cage nets, mooring bridles and sinker ropes (if required) and seal nets (if required) are supported off the base frames of the floatation ring. Fence nets and bird (top) nets are supported off the handrails and stanchions.

Figure 63.
EIS for a salmon farm site at Shot Head.
Operating facilties.
Generalised cage and farm layout and specification diagram.

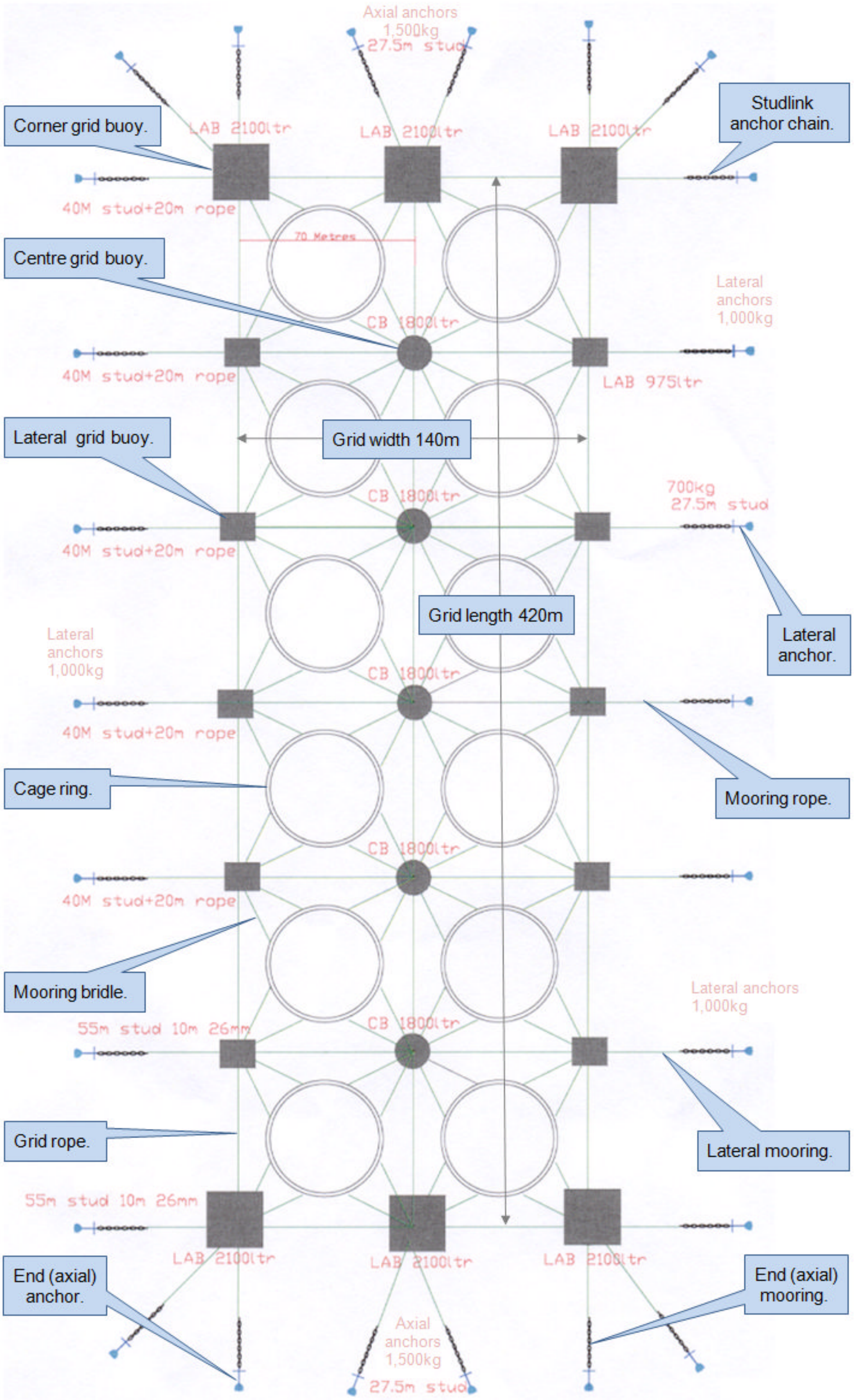
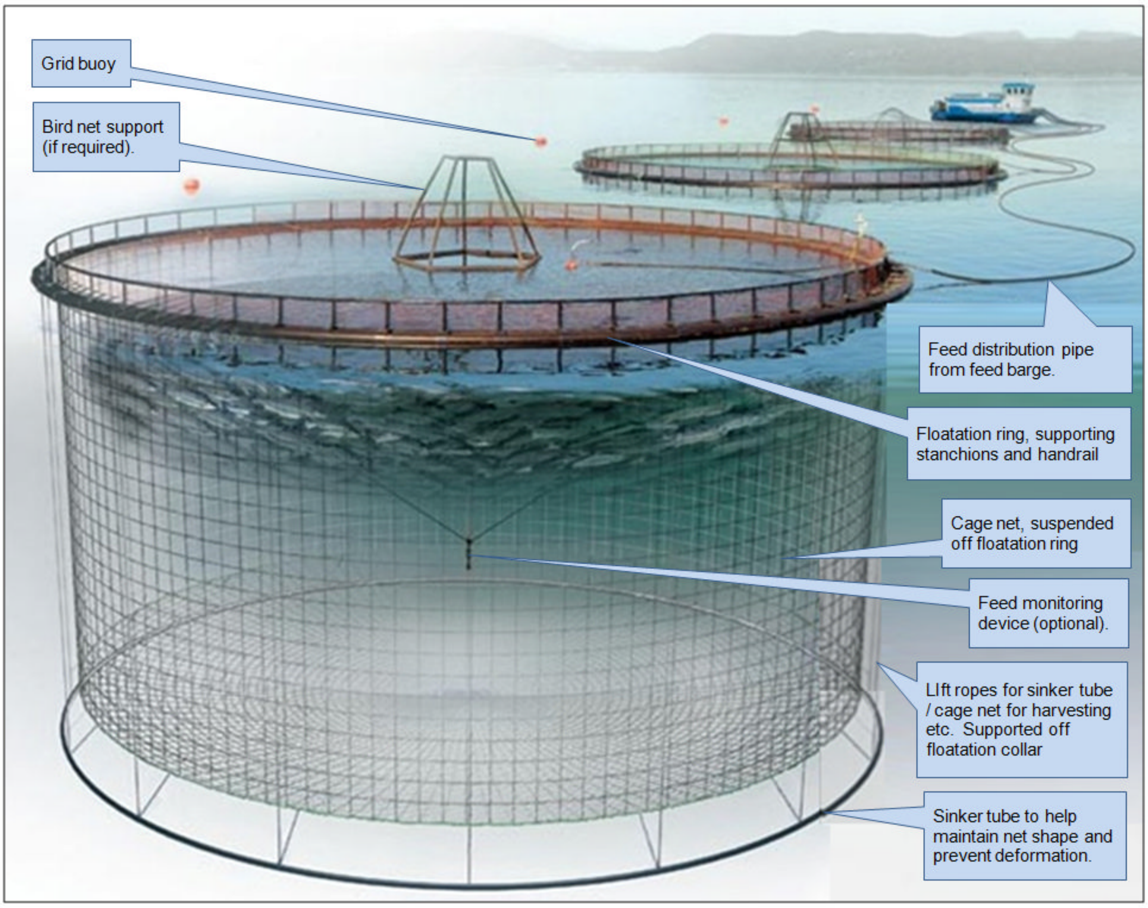


Figure 64.
EIS for a salmon farm site at Shot Head.
Operating facilties.
Floatation ring and generalised cage and farm layout.
Source lower image; Polar Cirkel AS.



3.3.3. Cage grid and moorings.

The cage floatation rings are held in place in the mooring grid by the mooring bridles. There are four sets of bridles on each cage ring as shown in Figure 63. The mooring grid is a heavy duty rope-work structure comprising a series of squares, each of which supports a cage. In this case, where the cage diameter is 41m, the side dimensions of each grid square are 70m x 70m. The grid for Shot Head unit would comprise a block of 6 x 2, 70m x 70m squares. Thus the dimensions of the entire grid are 420m x 140m, see Figures 4 and 63. The mooring grid is submerged such that farm work vessels can pass freely across it. At every grid square corner, there is a grid buoy supporting the grid. These are also the points at which the mooring bridles, which support the cage floatation rings within the grid squares, join the grid. The grid is then held in shape, submerged and in tension by moorings which, in turn, are anchored to the seabed. Single lateral moorings join the grid at every square corner down each side of the grid, whilst paired end (axial) moorings join the grid on every square corner at the ends of the grid (three sets at each end). There are 14 lateral moorings and 12 end moorings in toto, as shown in Figure 63.

The shape of the grid is maintained by the tension provided through the grid moorings. Each mooring assembly comprises a heavyweight braided nylon rope running from each grid corner, which is attached to a length of heavy duty link chain of specified weight, which is joined in turn to an anchor of specified design and weight. The purpose of the stud link chain is to maintain the tension on the grid with tidal variation in water depth. Mooring bridles are used to connect the four corners of each grid square to at least eight points on the cage ring within it. This maintains the position and shape of the cage ring within the grid square with minimal deformation, even in the worst sea conditions.

3.3.4. A note on site dimensions

As pointed out in Section 1.6, the only visible structures on the site will be the cage rings with bird (top) nets, grid buoys and the feed barge, with navigation lights and buoys. The cage rings have a circumference / diameter of 128m / 41m and an individual surface area of 1,300m^2. The number of cages deployed for the bulk of the 24-month production cycle will be twelve[30], with a combined surface area of 15,650m^2, or just over 1.5 hectares, within the site area of 42.5 hectares. The dimensions of the proposed Shot Head site and structures within it can be summarised as follows:-

[30] This will be increased to 14 cages by the addition of two temporary cages for the transfer of harvested fish during the harvesting season; see Section 3.4.6 and Figure 72.

- Actual surface area of the cages 15,650m^2 (1.56ha).
- Maximum horizontal length axial moorings 110m
- Maximum horizontal length lateral moorings 80m
- Grid length / width 420m x 140m
- Thus approximate area to the limits of seabed moorings 640m x 300m = 192,000m^2 (19.20ha).
- Overall site area to be applied for 850m x 500m = 42.5ha.

Site surface structural dimensions of the Shot Head site, as a percentage of the licensed area to be applied for are:-

- Actual cage surface area 3.67%.
- Area to the maximum limits of the moorings on the seabed 45.2%.

Site structural dimensions and site area proposed for the Shot Head site as an percentage of the water surface area Bantry Bay:-

- Cage surface area (main visible structure); <0.01%.
- Area to the limits of seabed moorings; <0.10%.
- Overall site area to be applied for <0.20%%.

3.3.5. Boats and service craft.

Site service will be provided by a purpose-built multi-cat type vessel powered by two 220Hp diesel Dossan engines and equipped with a 17 tonne-metre crane. Its dimensions are 15.5m overall length, 6.7m beam, with a 30-tonne capacity. The vessel will also be equipped with a raised aft wheelhouse, flat work deck, a pusher bow, raised gunnels and removable deck rails; see outline drawing in Figure 65. This vessel is suitable for transportation of feed and other freight, and general site duties, including maintenance and net changing.

The site will also be equipped with a Polar Cirkel type HDPE workboat of maximum length 8m, powered by a 50Hp outboard engine. See specifications in Figure 66.

SW operations share the use of the MV Conamara, which is equipped for net cleaning duties (see Figures 67 and 71). Equipment comprises an Idema K-188-399-SD-JD-150 power washer, deck-mounted aft of the wheel house, coupled to an Idema Model K188-30 net cleaning system with a seven-disc cleaning head. The cleaning head is raised and lowered down the nets using a winch and jib. This vessel can also fulfil a variety of other service roles as required. See outline specifications in Figure 67.

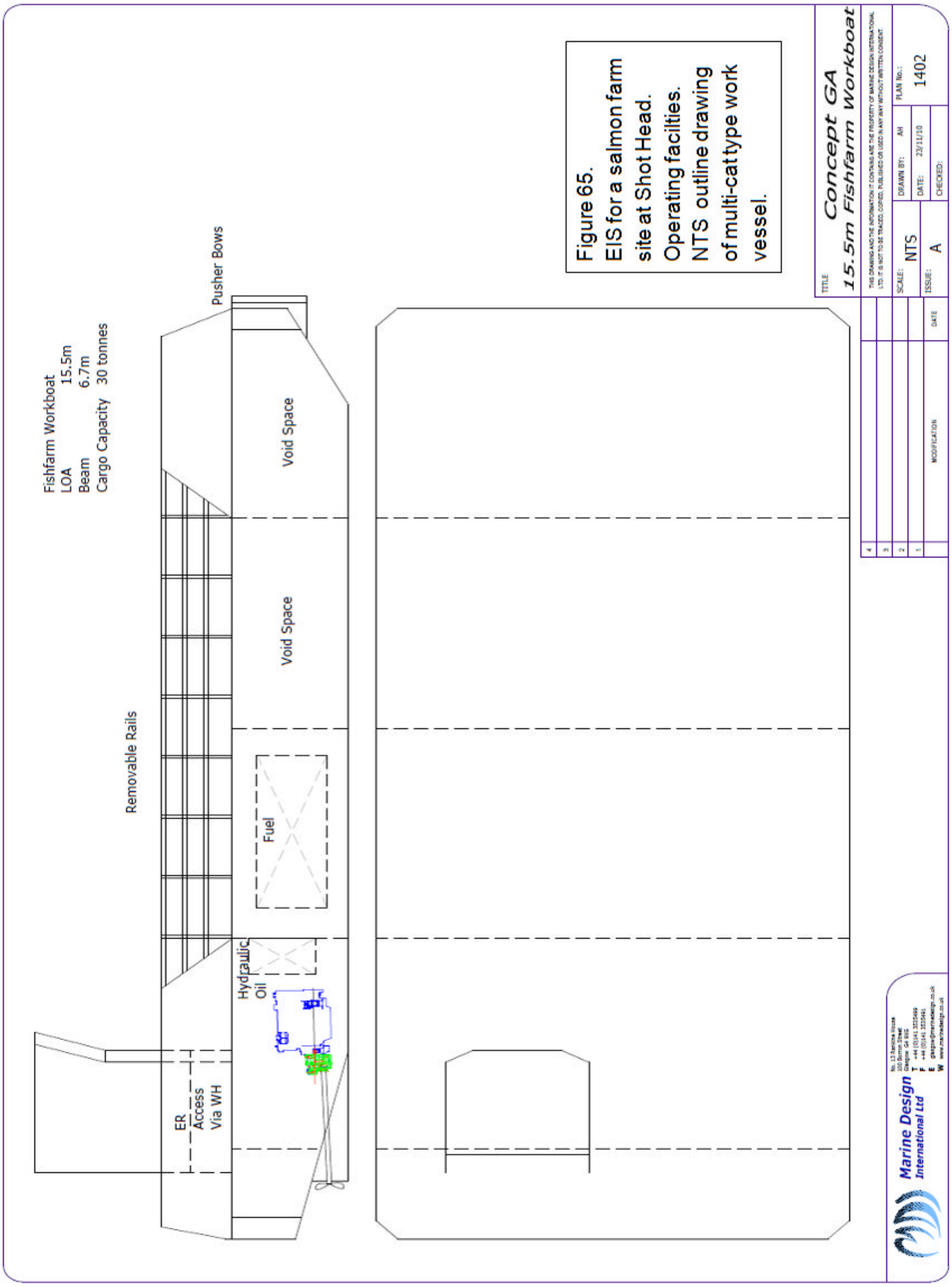


Figure 65. EIS for a salmon farm site at Shot Head. Operating facilities. NTS outline drawing of multi-cat type work vessel.

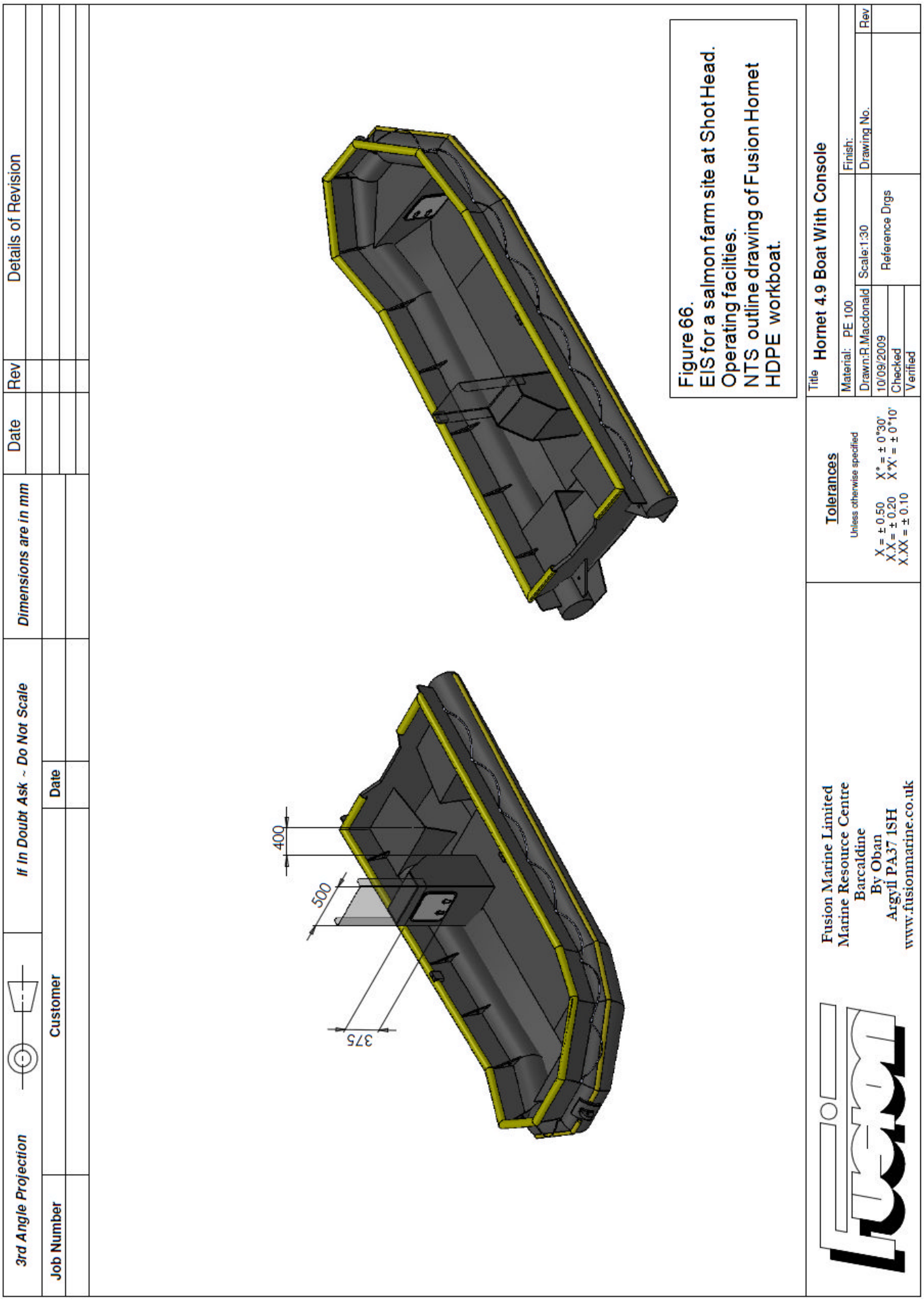
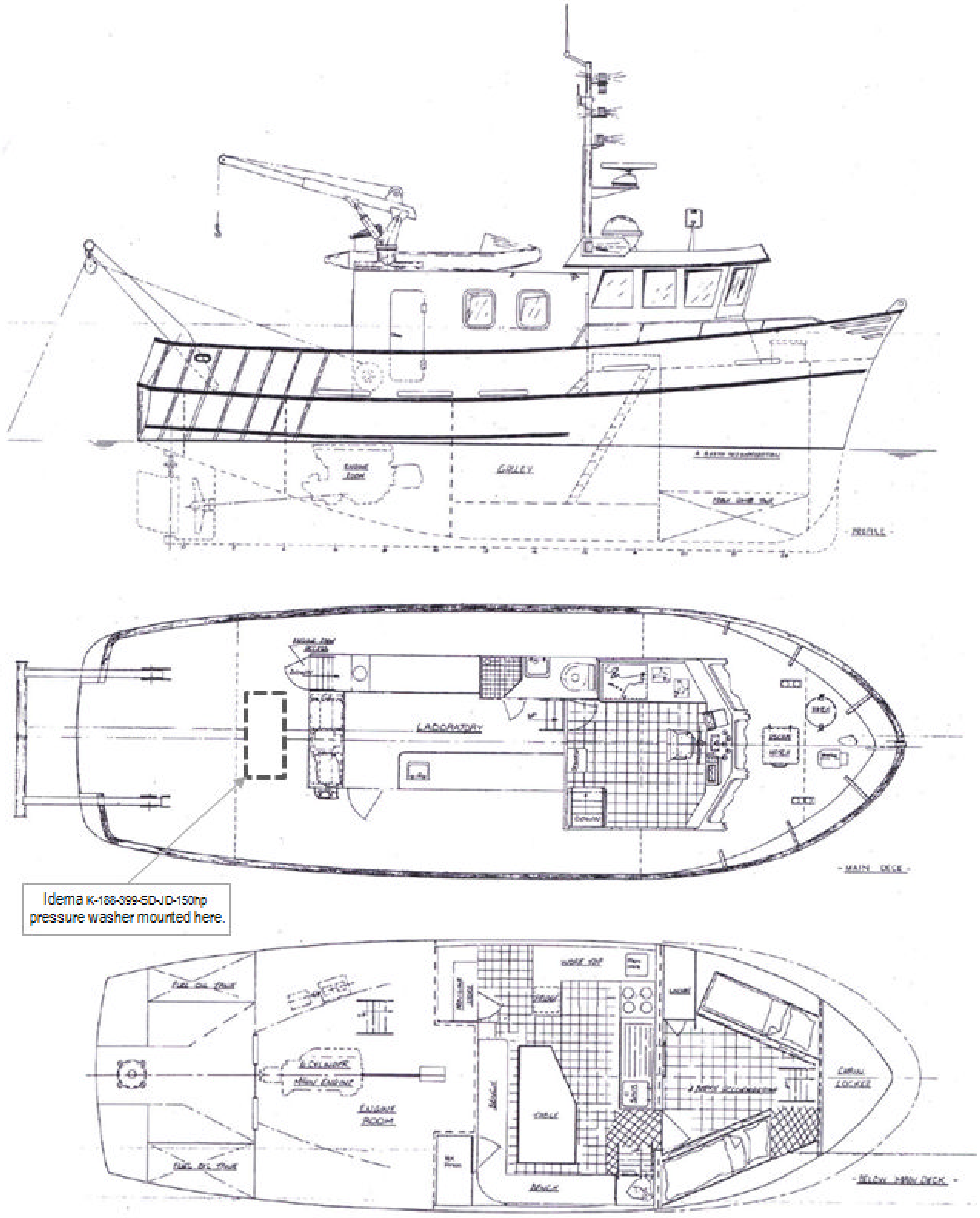


Figure 66.
EIS for a salmon farm site at Shot Head.
Operating facilties.
NTS outline drawing of Fusion Hornet HDPE workboat.

Figure 67.
EIS for a salmon farm site at Shot Head.
Operating facilties.
MV Conamara; general arrangement.



Overall length	13.88m	Draft	1.77m
Beam	4.62m	Main engine 275hp@1200rpm	
Depth	2.51m	Gearbox; twin disc 3.5:1 reduction.	

A well boat on permanent lease to the company, the MV Grip Transporter, will be used for the wide variety of activities on and around MHI operations that involve fish pumping, fish delivery, fish grading and fish bath treatment. The Norwegian-built and operated MV Grip Transporter, which is 60.4m in length, with a beam of 11m and draught of 4.45m, was built in 1993. It is powered by a reduced 969KW Caterpillar main engine, with a 93KW Caterpillar auxiliary engine. The vessel has a total well tank capacity for fish containment of 1,250m^3, six circulation pumps, substantial water chilling capacity and a 4-channel, 50kg per hour oxygen / ozone generation system. For fish moving, counting and grading, the vessel is equipped with two 5,000 litre vacuum pumps, two fish counters with a 200 to 300 tonnes per hour capacity and a 100-300,000 smolt per hour smolt counter plus a ten track, three-way grader with separate counters, capable of grading and counting up to 60 tonners of fish per hour. It is also fitted with six deck cranes of up to 24 tonne-metre lift. The two photographs in Figures 68 and 69 show the vessel at MHI site locations. Note fish coming through the grader and being distributed to two cages in Figure 69. The fish pipes are held in position by two of the onboard cranes.

The wide range of activities that the Grip Transporter is used for are described in detail in Section 3.4.

3.3.6. Vessel moorings.

The main service vessels will operate from existing moorings, either in the Castletownbere Harbour Area or at the Pontoon Pier at Beal Lough, east of Castletownbere. When vessels are moored off-pier, they will be accessed by Polar Cirkel workboat. This is a normal practice, especially when piers are crowded or when pier access is limited by tides. Under these circumstances, workboats are moored at piers to give staff easy access to larger vessels, when and where required. Piers local to Shot Head, in particular at Trafrask, have limited access due to tides but may be accessed by smaller vessels, such as Polar Cirkel workboats, from time to time, as necessary.

Figure 68.
EIS for a salmon farm site at Shot Head.
Operating facilties.
Wellboat MV Grip Transporter, Mulroy Bay, 29th July 2009.

Figure 69.
EIS for a salmon farm site at Shot Head.
Operating facilties.
Wellboat MV Grip Transporter grading cages at MHI Roancarrig, 2nd June 2010.

3.4. Standard Operating Procedures.

3.4.1. Husbandry and management.

The staffing arrangements for the proposed Shot Head site will be integrated into the staffing structure of MHI's southwest operations as a whole. Staff will operate and be managed under the many Standard Operating Procedures established by MHI for the operation of their business some of which are appended in Appendices 2 to 4.

Eight additional full-time husbandry posts will be created as a result of the development of the proposed Shot Head site to full, steady-state production. The employment of additional personnel will be phased as production increases on the site, with five new employees required at the commencement of operations.

3.4.2. Feeds and feeding.

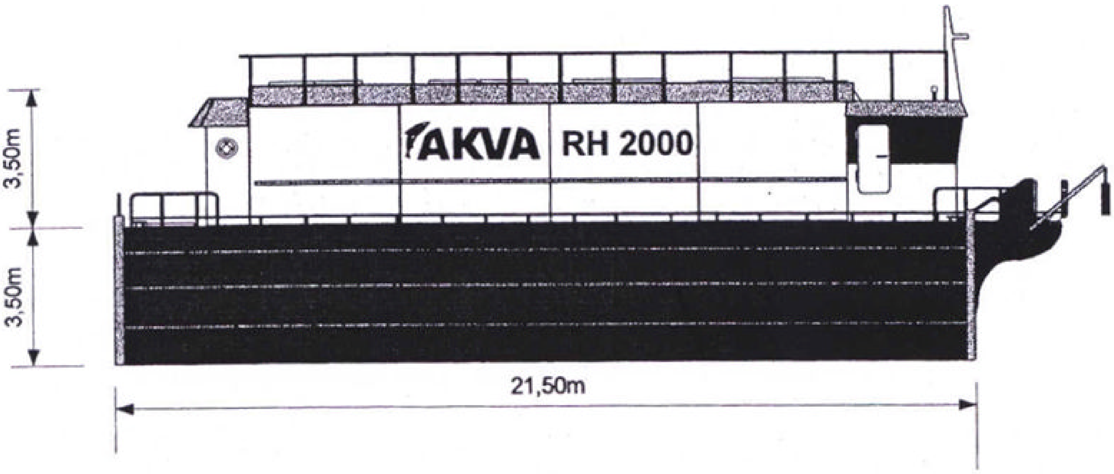
The feeds used for all of MHI's organic farming operations are dry salmon feeds, manufactured to the appropriate Organic Standards (see Section 1.2) and supplied under contact from one or more of the specialised salmonid feed manufacturers supplying the European and global markets. The feed specifications used in the growth models and discharge models in Sections 3.1, 3.2 and 4 of this document are BioMar Ecolife Pearl organic rations, manufactured by BioMar UK. As will always be the case with rations used for organic production by MHI, Ecolife Pearl products comply with EU Directives 834/2007/EC and 889/2008/EC as amended by 710/2009/EC and are certified to the organic standards set by a number of international organic certifiers, in this case the Organic Food Federation (UK), Naturland (Germany) , and Agriculture Biologique France; see Appendix 5

In order to meet the requirements of organic certification, Ecolife Pearl is produced utilising a limited selection of raw materials, mainly comprising trimmings-derived fish meals and marine oils, organic wheat and other organic plant raw materials, natural pigments, natural anti-oxidants, and only organic-approved vitamins and minerals. Every ingredient batch supplied is certified to be of organic standard prior to purchase by the manufacturer. Raw materials are sourced and feed formulations composed to meet the full nutritional requirements of salmon as well as to optimise Feed Conversion Rate and minimise faecal waste by maximising ingredient digestibility. This is achieved without compromising the organic status of the stock. Nutritional requirements of salmon and the processes of feeding, growth, metabolism and waste production are discussed further in Section 4.

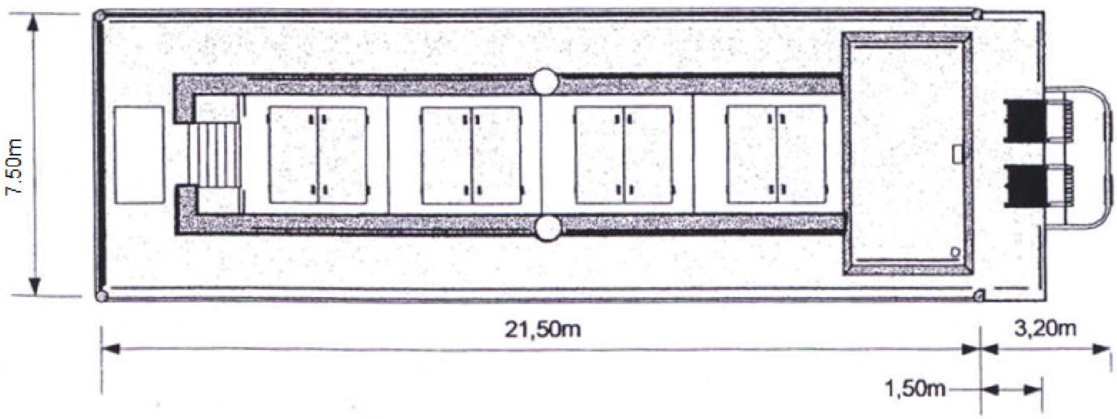
It is proposed to deploy a feed barge on the shoreward, most sheltered (northern) side of the cage grid as shown in Figure 4. The purpose of the feed barge is to feed the stock automatically throughout daylight hours and, thereby, to optimise Feed Conversion Rate and to minimise waste. A dimensioned diagram of the proposed feed barge is shown in Figure 70.

Figure 70.
EIS for a salmon farm site at Shot Head.
Operating facilties.
Akva RH2000 Feed Barge; outline specification drawings; NTS.

Side elevation



Plan



The amount of feed fed to each cage is calculated and consequent growth projected using an onboard computer and feed dosing system. The weight of feed fed is calculated using outputs from load cells mounted on the individual feed silos. The feed is delivered to individual cages via a manifolded pipe distribution system using compressed air; see feed distribution pipe in Figure 64. The feed barge type is expected to be an AKVA RH 2000 or similar, with a nominal length of 22m and a beam of 7.5m. Total capacity of the barge will be of the order of 200 tonnes of feed, held in four silos, each with its own feed delivery system; see Figure 70. Feed will be delivered directly to the feed barge by sea from Castletownbere.

3.4.3. Net cleaning, maintenance and changing.

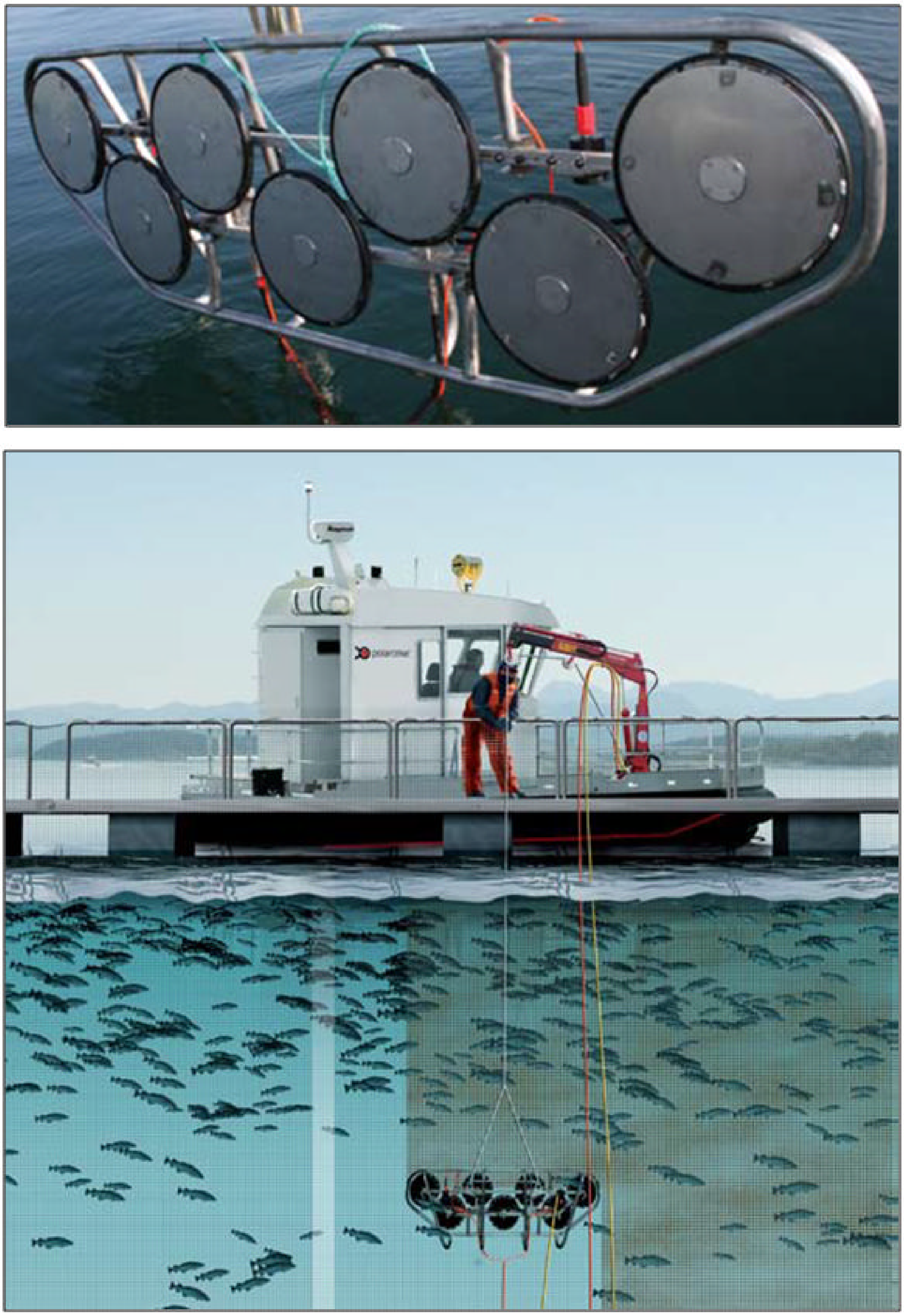
Cage nets will be made of knotless nylon sheeting. In compliance with organic standards, no net antifouling treatment will be used at the proposed Shot Head site. This applies to all MHI organic sites. Smolt nets, with a smaller mesh size than grower nets, will be installed at the beginning of the cycle. These will be made of 210/120 braided twine, with a 16mm mesh. The smolt nets will be changed in the late spring after about six months and replaced with grower nets, made of 210/240 braided twine with a mesh size of 32mm.

Nets will be cleaned in-situ on a regular basis throughout the growth cycle using a 7-head K-188-30 Idema net cleaner, linked to an Idema K-188-399-SD-JD-150, 150hp, diesel-powered pressure washer, which is mounted on the MV Conamara. The cleaning head is raised and lowered up and down the sidewalls of the cage using a jib and capstan, also mounted on the vessel. The net washing system and mode of operation are illustrated in Figure 71. Net cleaning and Idema washer maintenance are carried out as per the Standard Operating Procedures (SOP25468 and SOP 25474), appended in Appendix 2.1.

Nets will only be changed further when the need arises. Regular diver inspection is used to check for net damage. Minor repairs are generally made by divers in situ whilst washing, disinfection and larger repairs are carried out either in the company's regional operations yard on Dinish Island, Castletownbere or in the company's main Net Bay at Scraggy Bay, Lough Swilly, Donegal. Net checking, changing and mending are carried out as per the Standard Operating Procedures (SOP 28941, SOP 26166 and SOP 28646) appended in Appendix 2.1.

Dark-coloured bird (top) nets will be used to protect the stock against bird predation throughout the life cycle.

Figure 71.
EIS for a salmon farm site at Shot Head.
Operating facilties.
Net cleaning with the Idema net washer.
Image source: Akvasmart



3.4.4. Cage, grid and mooring management.

The deployment and mooring of cages are covered by Standard Operating Procedures SOP25462 and SOP26338; see Appendix 2.2. Grid-moored systems require the application of more or less even tension on all moorings to keep the grid taught. Tension is maintained by the use of adequate moorings, anchor chains and anchors (see Figure 56), to suit seabed and hydrographic conditions and the dimensions of the system; see also Sections 3.2.3 and 3.3.3. Grid frame integrity is checked biennially by divers; see Standard Operating Procedure SOP28940 in Appendix 2.2.

3.4.5. Smolt delivery.

Smolt are size-graded and counted at the hatchery prior to transportation to cage sites. Smolts destined for the southwest are trucked from the MHI hatcheries at Lough Altan or Pettigo to either Killybegs County Donegal or Castletownbere. They are then loaded onto the well boat for delivery to site. Smolt delivery is covered by Standard Operating Procedure SOP25478; see Appendix 2.3. In general smolts are check-counted as they are released into each cage from the well boat.

3.4.6. Grading.

Stock are normally graded on the grower site at a mean weight of about 2.5kg, which is reached in the winter of the second year, about 12 months after transfer. The, cages are lifted to concentrate the fish which are then pumped into the grader on the deck of the MV Grip Transporter well boat or similar. Cage nets are lifted individually to concentrate the fish, which are then pumped through the grader, where they are graded by girth (which has a fish mean weight equivalent). The fish are then counted prior to distribution to destination cages. Figure 64 shows grading ongoing at the MHI Roancarrig site. The grader is in the foreground and two distribution pipes, supported by cranes, are channelling fish of separate mean weight ranges into two destination cages If necessary, individual grades can be held in well boat tanks to await the emptying of source cages prior to redistribution. Grading helps with the accounting of fish stocks, interrupts the development of peer groups within the cage, reduces aggression, improves feeding, promotes more even growth and improves the evenness of fish weight at harvest. Standard Operating Procedures for fish grading (SOP 23009) are given in Appendix 2.3.

Another grading procedure, *passive grading* is used in preparation for harvest. This employs a passive grading panel with specifically-sized "slots" to retain the selected size of fish required. This is stitched into a seine net or similar. The slots in the panel are generally made of flexible pieces of plastic piping which are woven into a mesh to prevent damage to the fish as they are retained or pass through the panel. The passive grader is introduced into a cage where a good proportion of the fish are close to, or have reached the appropriate harvest mean weight. The fish are left, behind the grading panel, generally overnight. The smaller fish then swim through the passive grader, leaving harvest-sized fish ready for removal from the cage. During this pre-harvest stage, in months 14 to 22 of the cycle, the number of cages on site may be temporarily increased from 12 to 14, as necessary, to accommodate groups of fish ready to be harvested. The difference between 12-cage and 14-cage layouts is shown in Figure 72.

3.4.7. Harvesting and processing.

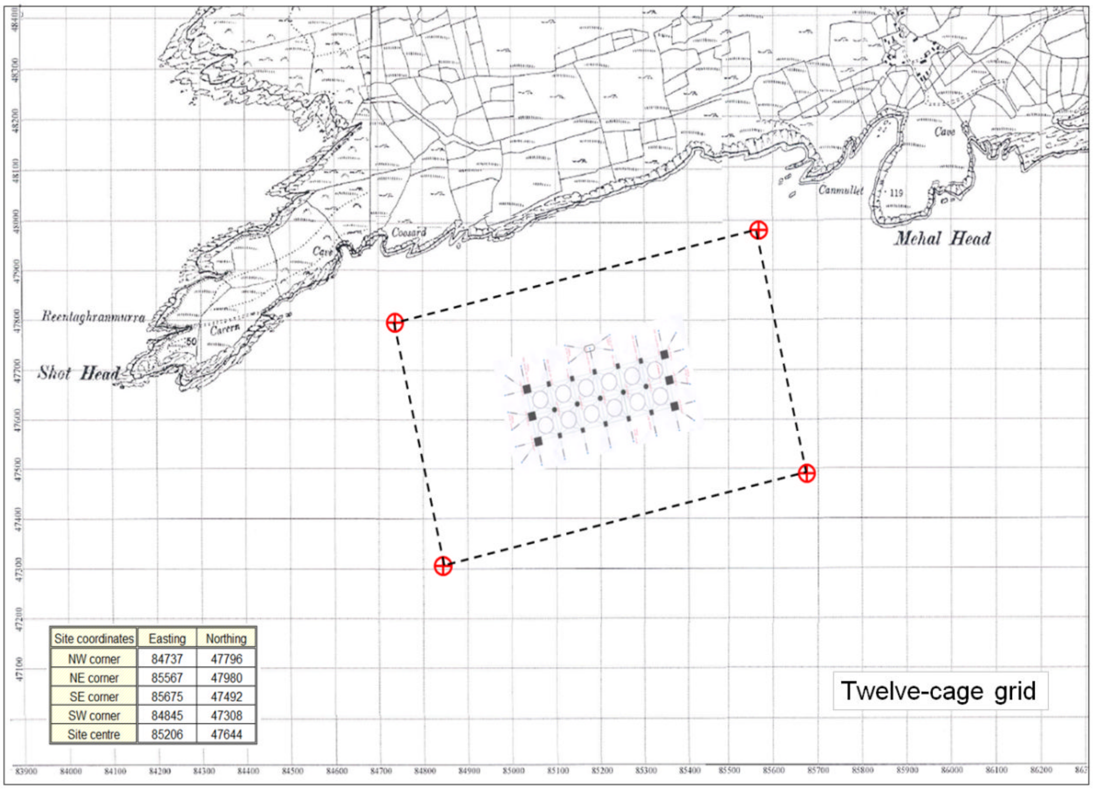
The harvesting period for stock at the proposed Shot Head site will run between months 17 and 22 of the production cycle. Harvesting is the final process in the cycle requiring the use of a well boat. Fish already selected for harvest by passive grading are pumped into the well boat tanks, where they can be retained live and in good condition while the tanks are filled. Once loaded, the fish are transferred to Castletownbere port, where they are transhipped, via the well boat pumps, to chilled tanker transport. The fish are then transported to the Millstone Harvesting Station, in Donegal, where they are slaughtered using the SI-5 flow-through humane stunning system. This irreversibly stuns the fish with a single blow, following which they are manually cut through both gill arches, and bled, before transfer to the MHI Packing and Processing Station at Rinmore, County Donegal; see Standard Operating Procedures SOP25499 and SOP29149 in Appendix 2.3.

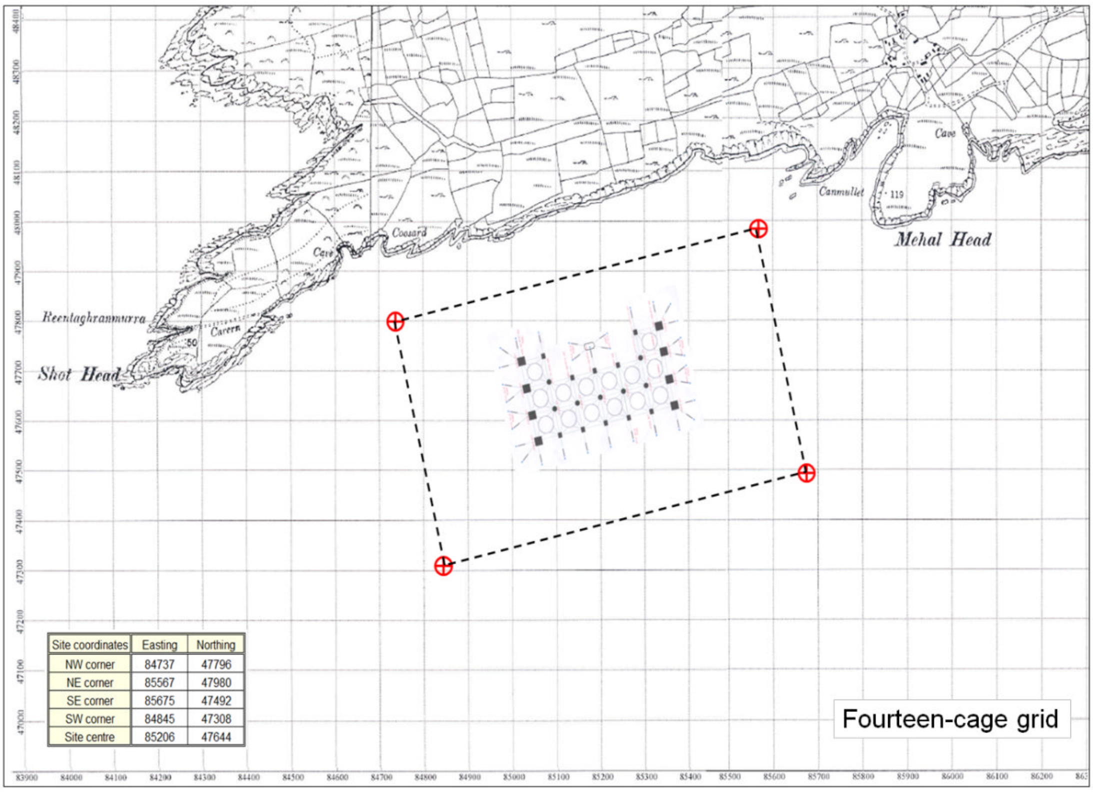
3.4.8. Mortality disposal.

Routine mortalities are disposed of under the Standard Operating Procedure for Waste and Waste Management (SOP25564; see Appendix 2.4), which covers the matter of the management and disposal of all routine wastes from MHI installations. Mortalities are removed from cages by divers at least once a week, or more frequently subject to observed mortality trends. Collected mortalities are taken for incineration at College Proteins of Nobber, County Meath, an approved animal by-products rendering plant, as required by Department of Agriculture, Marine and Food guidelines.

Culled fish and mass mortalities are dealt with under a separate SOP; see Section 8 and Appendix 4.3.

Figure 72.
EIS for a salmon farm site and Shot Head.
Operating facilties.
Comparison of layouts of standard 12-cage grid and 14-cage harvesting grid.





3.4.9. Health management.

Heath management on all MHI sites is conducted according to the Fish Health Management Plan, appended in Appendix 3.1. The plan underpins the company's obligations under EU and national legislation, namely:-

- 2006/88/EC and SI 261 of 2008 (Health of Aquaculture Animals and Products).
- 2001/82/EC and SI 14 of 2007 (Animal Remedies Regulations).
- 1774/02/EC and SI 248 of 2003 (Animal By-Products Regulations).

The main goals of the Fish Health Management Plan for Marine Harvest Ireland are as follows:-

- To prevent and control fish diseases and ensure the maintenance of a high level of fish health and welfare.
- To minimise environmental impact.
- To rear salmon in accordance with industry guidelines and the current best practices of the industry.

The primary actions of the health plan are:-

- Vigilance and regularity in stock monitoring against key performance indicators.
- Disciplined and detailed record keeping.
- Official notification in the event of disease outbreaks.
- Application of therapy under veterinary supervision / prescription, in strict adherence to the organic standards that will apply at the site.

The health plan lays down that observation of the stock, from which all remedial actions will stem, will comprise:-

- Daily (surface) observations of fish behaviour by site managers and feeding operatives, as well as during routine operations such as feeding and net changing.

- Fully qualified diver observation of behaviour and general fish health at least weekly or more frequently, subject to mortality trends, with recording of all mortalities by number and likely cause of death.

- A minimum of bimonthly clinical examination of all stocks by the contracted veterinarians, Vet-aqua International of Oranmore Business Park, County Galway, plus a 24-hour consultation service in the event of a disease event.

3.4.10. Treatment of disease.

The treatment of disease is covered by the Standard Operating Procedure SOP 24337; see Appendix 3.1. The MHI Positive Medications List describes the standard medicines used for marine stocks reared under Organic Standards (see Appendix 5). The majority of the medicines permitted are supplied on the advice of the company's consultant veterinary surgeons, on prescription.

MHI takes a prophylactic approach to the susceptibility of stock to exposure to the most common infectious diseases, by the use of vaccination, prior to transfer to seawater. MHI currently uses two of three vaccines, all of which are permitted for use in organic stock:-

- Alpha Ject 3000; manufactured by Pharmaq. A bivalent IP injectable fish vaccine, protecting against the commonest, endemic bacterial diseases, Furunculosis (causative agent *Aeromonas salmonicida*) and Vibriosis (causative agent *Vibrio anguilarium*)

- Norvax Compact PD; manufactured Intervet Schering Plough. An IP injectable fish vaccine, containing inactivated PD virus, to promote immunity against Pancreas Disease virus.

- Norvax Compact 4; manufactured by Intervet Schering Plough. A trivalent IP injectable fish vaccine to promote immunity against three bacterial diseases; Furunculosis, Vibriosis and Cold Water Vibriosis (causative agent *Vibrio salmonicida*); not currently used.

As a generalisation, farmed fish are affected by a small range of "domestic" diseases, much as other domesticated stock. Some are indigenous to local wild fish species. The most common are treated prophylactically with vaccines. Their symptoms are well known and treatment is applied as a matter of routine, under the relevant SOP's. This applies in particular to salmon louse (*Lepeophtheirus salmonis*) infestation, which is dealt with in detail in Section 5.

Although new or unrecognised diseases do occur, their antecedents can, more often than not, be found in other salmon farming areas such as Norway or Scotland. However, such occurrences are unusual and, in consequence, occurrences are treated with the utmost urgency by both the company and its veterinary consultants. Industry over many years is that disease is frequently preceded by stock stress, caused, for example, by overcrowding, high temperature / low oxygen, poor nutrition or stock predation. Farming to organic standards reduces or eliminates many of these stressors which has led to a radical reduction in disease outbreaks and in the frequency of treatment.

In the event of an outbreak of bacterial disease, which is normally indicated by fish behaviour, or other symptoms, such as appearance of indicative lesions, moribund fish or mortality, the standard operating procedure entails isolation of the pathogen from a standard range of tissues and testing against a range of antibiotics to establish a sensitivity pattern so that the best treatment can be selected. Frequently however, treatment must start on the best available information before completion of sensitivity testing in order to limit losses. Non-vaccine treatments for fish disease take one of two forms. They can be applied in medicated feed, in which case the prescription medicine, supplied as a powder, is surface-dressed onto a standard feed ration. These are generally mixed to veterinary prescription by feed manufacturers. Alternatively, soluble treatments can be applied to the fish in a medicated bath. In the past such treatments have been carried out in shallowed, skirted or bagged cages. However in MHI's case, bath treatments are generally applied using well boat tanks. This reduces the quantity and cost of medication required and also greatly reduces the release of spent medication into the wider environment on completion of the treatment. Whilst antibiotics are generally applied in medicated feeds, both in-feed and bath type lice treatments are available; see Section 5.

3.4.11. Predator control; mammals.

Notes on the distribution and biology of local marine and terrestrial mammals where there is any potential that impacts could arise from the proposed Shot Head site farm are given in Sections 5.3.4 and 5.3.5. This present section deals only with the needs for the control of predation by such species, that frequent the area.

Eleven or so cetacean species[31] have been observed in the waters off the south west coast of Ireland, of which about three, the common

31 Whales, dolphins and porpoises.

dolphin (*Delphinus delphis*), the bottlenose dolphin (*Tursiops truncatus*) and the harbour porpoise (*Phocoena phocoena*), are quite common in Inner Bantry Bay. Rarely, other species, which normally inhabit deeper or more offshore waters, such as Risso's dolphin (*Grampus grisseus*), Atlantic white-sided dolphin *(Lagynorhynchus acutus*), northern bottlenose whale (*Hyperoodon ampullatus*) and minke whale (*Balaenoptera acutorostrata*) are observed in the inner bay[32]. However cetaceans rarely interact with marine farm sites and are not regarded as a predator hazard.

Few grey seal (*Halychoerus grypus*) inhabit the inner bay, preferring more exposed habitats further west. However Inner Bantry Bay is one of Ireland's main haul-out areas for harbour (common) seal (*Phoca vitulina*)[33]. This species comes ashore at haul-out sites to give birth in June and to moult during July and August. Many of the haul-out sites in Bantry Bay are in or adjacent to Glengarriff Harbour, within SAC 000090, which lists the harbour seal as an Annex II Habitats Directive species. There is a further cluster of haul outs at the western end of Whiddy Island.

The closest haul-outs are approximately 5km from the proposed Shot Head site area and there is a likelihood that seals will visit the site. It will therefore be necessary to assess whether or not anti-predator nets or even seal scarers will be needed to protect the stock from seal attack early in the development of the site, if the licence is granted.

On occasions, terrestrial mammals in particular otters, visit marine salmon farm sites. However, in this case, shoreline terrain, proposed distance of the cages from the shore and the integrity of surface fence nets and bird nets are likely to preclude any possibility of otter predation in the highly unlikely event that the species visits the site.

3.4.12. Predator control; birds.

Notes on the distribution, biology and an assessment of the risks that impacts on local bird populations could arise from the proposed Shot Head site farm are discussed in Section 5.3.3. This section deals only with the likelihood of and control of intrusive bird activities at the site.

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32 Heardman C Ed. Bantry Bay Biodiversity Audit and Management Plan. 2010-2015. NPWS.

33 Cronin M et al. 2004. Harbour seal population assessment in the Republic of Ireland 2003. Irish Wildlife Manuals No. 11. © National Parks and Wildlife Service.

A wide range of sea bird species frequent the inner Bantry Bay area, as residents, or as common and rare winter and summer visitors. The most populous resident species are the common gull, the herring gull, the greater black-backed gull, and cormorant.

Seabird species are quite frequent visitors to fish farm sites but if reasonable measures are taken against predation, such as the correct installation and fixing of bird nets, most species do nothing more than perch until disturbed. Without the secure attachment of bird nets at the beginning of each production cycle, gulls in particular quickly learn that salmon smolt make easy pickings, especially at dawn and dusk before staff arrive on site. Gulls are also habitual followers of fish farm vessels as they are with fishery vessels.

Cormorants are the most persistent avian predators of farmed fish. They are capable of breaching the cage nets underwater and on occasions will also breach bird nets, to predate on the salmon stock. There was controversy for some years regarding the protection of the cormorant under Annex I of the Birds Directive. This protection was removed in 1997, mainly because of the evident success of cormorants as fish-eaters and scavengers, following their near extinction in the past.

There is at least one nationally important breeding colony of cormorants in Bantry Bay but experience at the MHI Roancarrig site suggests that cormorant should not prove problematic at the proposed Shot Head site as long as the stock is adequately protected. In the event that fence nets are required as protection against seals, this will also protect against diving cormorants.

Section 4.
Potential impacts of the farming process on sediment and water quality.

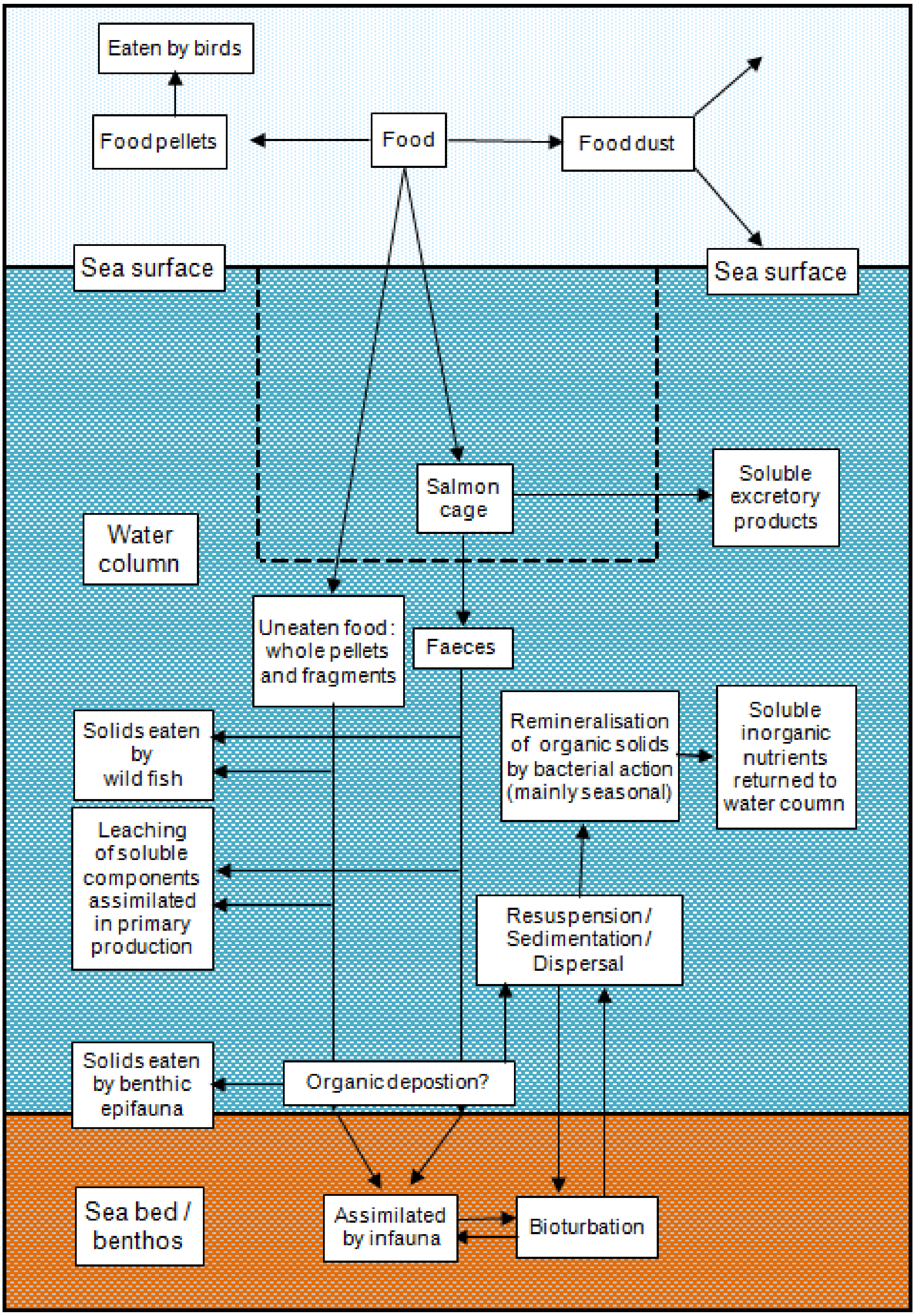
4.1. Feeding, metabolism, growth and waste.

All human activities produce waste. In animal husbandry, food fuels growth and waste is an unavoidable consequence of the feeding process. Salmon farming is, in the main, an organic process, which therefore produces a mainly organic waste. This is particularly the case for organically certified farming, where non-organic interventions, such as the use of net antifoulant, are disallowed. Sustainable quantities of organic wastes are non-toxic and are readily assimilated by the organisms that inhabit the water column and the seabed. The majority of waste by weight arises from the non-digestible fraction of the feed consumed. These solid wastes are excreted into the water column through the anus of the fish, as faeces. Much of the balance is voided in solution, mainly via the gills and skin, being the equivalent to urine in mammals. Soluble wastes are mainly the unwanted nitrogenous end products of the metabolic processes involved in feed utilisation for energy provision and growth. A further small amount of waste arises from waste feed, which remains uneaten.

Figure 73 shows that a small fraction of feed may be lost into the air or sea as dust, or possibly to birds as whole pellets. However these waste routes are minimised by current expanded pellet technologies and by the use of feeding systems, which deliver the feed close to the water surface and under bird nets. The carbohydrate content of fish feed mainly comprises wheat starch, which has a nutritional value but is also used to modify both the buoyancy and robustness of the pellet, by its controlled expansion in manufacture. This minimises chipping and dust generation from the finished, pelleted product.

The pellets are designed sink slowly, increasing their availability to stock. As a result of feeding, the fish produce both soluble excretory products and faeces. Faeces, and a small proportion of the feed rejected by the fish sink through the cage net, where some may be eaten by wild fish or by epifauna at the seabed. There is some leaching of soluble nutrients from sinking particles into the water column. Nowadays feed waste has been reduced to a practical minimum. A figure of 3% food waste is now used as a basis for growth and discharge modelling. At the seabed, all organic deposition is reworked and assimilated by the benthic biota and dispersed, if deposited in sustainable amounts. Excess organic deposition may impact on seabed communities, as discussed in Sections 2.8 and 4.2.1.

Figure 73.
EIS for a salmon farm site at Shot Head.
Feeding, metabolism, growth and waste.
Sources and fate of wastes (after Gowan R).



The metabolic pathways followed by ingested food are as follows:-

4.1.1. Growth.

Growth comprises the recombination of suitable molecules from the digested portion of the feed ingested, into body tissues. The main building blocks of growth are amino acids, which arise from the splitting of protein molecules by proteinase digestive enzymes. Amino acids are then rebuilt into new combinations to form specific body proteins which, along with fatty acids, arising from the digestion of ingested fats, and other digested constituents such as carbohydrates, minerals and vitamins, combine in the syntheses of a range of many new tissues.

4.1.2. Energy.

Energy is derived from the "burning" of digested feed proteins, fats and carbohydrates through the animal's metabolism. Energy fuels body processes, such as growth, metabolism, movement and body maintenance. For salmon, fat is the most energy-efficient, environmentally benign and cost-effective energy source. Although protein can be broken down to give a source of energy, it is the least efficient and results in the wasting of valuable components that could otherwise be used for growth. For this reason, modern salmon rations are formulated with higher levels of more nutritionally valuable fats than in the past, for more efficient energy provision and higher quality body fat, in the finished product. At the same time, lower levels of higher quality, more digestible proteins are used, based on ingredient formulations which combine the twenty or so different amino acids that they contain in proportions that optimise growth per unit of protein fed.

4.1.3. Metabolism.

Metabolism is the collective term for all body processes at molecular level, including the various chemical pathways followed by the constituents of digested feed, through which an organism runs its living systems. Growth, energy provision and waste generation are all metabolic processes. The fuel (energy) and various other essential molecules and minerals required to run metabolic processes are provided by the feed.

To all intents and purposes, farmed salmon depend entirely on the feed provided by the farmer. For efficient production, growth and good animal welfare, it is therefore essential that their diet is as complete as possible. A great deal of research and development has gone into the perfection of cost effective, complete salmon rations for all stages of the growth, maturation and breeding of salmon in recent years.

4.1.4. Discharged waste.

The waste discharge streams that arise from salmon production, shown in Figure 73, can be categorised as follows:-

- Solid (insoluble) wastes:-
  - Faeces; the undigested and indigestible parts of the feed.
  - Uneaten feed; pellets, pellet chips (sinking) and dust (floating).

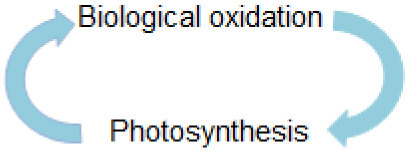
- Soluble wastes:-
  - Soluble excretory products, primarily ammonia and urea, arising from metabolised parts of digested protein. These are unwanted for growth and other metabolic processes and are toxic to the system beyond a certain concentration.
  - Solutes that leach from faeces and uneaten feed.
  - Remineralised solutes from the biodegradation of insoluble wastes.

In the main, solid wastes sink, at varying rates, dependant on their size and buoyancy, to the seabed, where, if they are able to accumulate, they can cause organic loading. This is dependent on deposition rate per unit seabed area, water depth and currents. Of course, the objective of sustainable salmon farming is to minimise waste accumulation. Solids are grazed down and metabolised by wild fish and other organisms as they sink and by demersal fish and benthic organisms, including bacteria, once on the seabed. Once on the seabed, organic matter is drawn into the sediments by the process of bioturbation, where it is assimilated and mixed with other biodegrading material and sediment particles by benthic deposit feeders and bacteria. Soluble wastes are absorbed and metabolised in the process of primary production by phytoplankton and macroalgae and also used as a nutrient source by zooplankton and bacteria, in the water column.

The amount and content of waste generated by salmon farming is a consequence of many factors, summarised in Figure 74. Due to advances in salmonid feed formulation and production and feed application technology, the amounts and impacts of salmonid farm waste, per unit of feed fed and per unit growth, have reduced in recent years. The main advances in ration formulation have comprised the “sparing” of protein as an energy source by increased oil use, the increased digestibility of protein sources and the better tailoring of protein content to give a closer fit to the precise essential amino acid requirements of the species. This has resulted primarily in improved feed conversion rates (FCR), faster growth rates and reductions in the solids and nitrogen content of salmon farm wastes. This has in turn resulted in a reduction in the Biological Oxidation Demand (BOD) of farm wastes arising from salmon farming. BOD is the amount of oxygen required (mainly by bacteria) to assimilate organic waste to its most oxidised state. This is the point where wastes will no longer deplete the oxygen saturation of the surrounding environment.

Biological oxidation is one of two main process steps in the Carbon Cycle, through which organic matter decomposes, to be rebuilt by primary production of plants through the "opposite" process step of photosynthesis (see reference to seasonal cycles in Section 2.7):-

Waste matter (primarily C+H+O) + $O_2 \rightarrow CO_2 + H_2O$ + energy



$CO_2 + H_2O$ + energy (sunlight) $\rightarrow$ plant matter (primarily C+H+O) + O_2

Like any life process, the feeding, growth and waste production of salmon and the assimilation of the wastes produced are a complex mix of inter-dependant processes, in a continual state of flux. The latest salmonid farming methods offer the means to maintain a sustainable and dynamic balance between these processes, such that wastes produced can be naturally assimilated, leaving the environment relatively unaltered and quickly refreshed by regular fallowing. Thus, if conducted with attention to the principals of proper environmental management, salmonid farming offers a means by which human food can be produced in an efficient and sustainable manner. This applies in particular to organic salmon farming which must be conducted by set standards in an environmentally benign and sustainable way.

4.2. Feeding efficiency and organic waste loading parameters.

The *Feed Conversion Ratio* (FCR) is important in the consideration of waste loading because it is a measure of an animal's efficiency in feed utilisation. FCR is the ratio of the dry weight of feed fed per unit (wet weight) growth of stock. For example, if it takes 1.25kg (dry weight) of feed to grow 1.0kg (wet weight) of fish, the FCR is 1.25 : 1. Many factors can affect FCR, as shown in Figure 74. It is the aim of modern fish farming to control these factors and, thereby, to improve the efficiency of feed utilisation. The effect of this strategy is to reduce waste production, as FCR reduces; see Figure 75.

Figure 74.
EIS for a salmon farm site at Shot Head.
Feeding, metabolism, growth and waste.
Factors affecting Feed Conversion Rate (FCR) and the relationship between FCR, organic loading and growth.

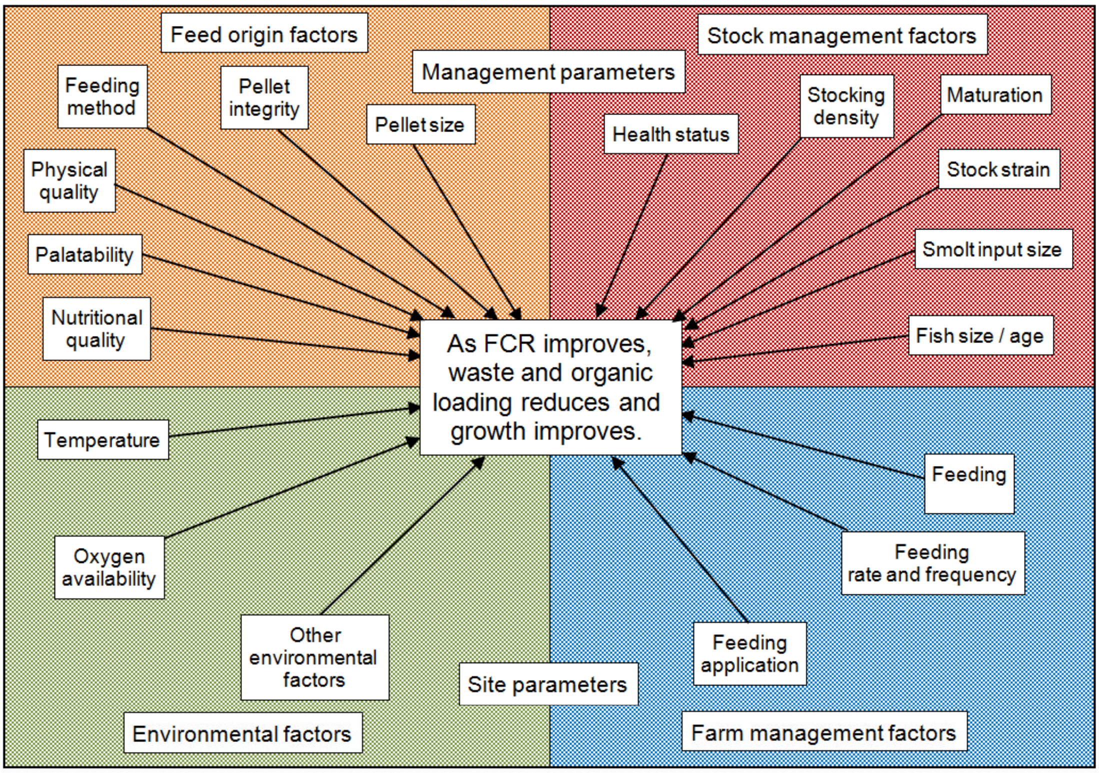
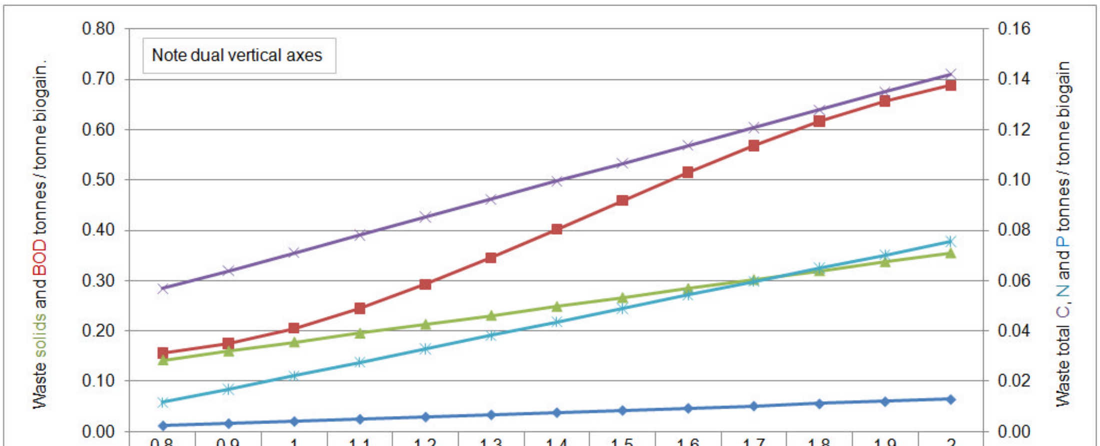


Figure 75.
EIS for a salmon farm site at Shot Head.
Feeding, metabolism, growth and waste.
Variation of main discharges with variation in FCR between 0.8 : 1 and 2.0 : 1.
For BioMar Ecolife Pearl 12mm ration; 37.9% protein and 0.9% phosphorus.



	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2
BOD	0.16	0.17	0.21	0.24	0.29	0.35	0.40	0.46	0.52	0.57	0.62	0.66	0.69
Solids T	0.142	0.160	0.178	0.195	0.213	0.231	0.249	0.266	0.284	0.302	0.320	0.337	0.355
Total C T	0.057	0.064	0.071	0.078	0.085	0.092	0.099	0.107	0.114	0.121	0.128	0.135	0.142
Total N T	0.012	0.017	0.022	0.028	0.033	0.038	0.044	0.049	0.054	0.060	0.065	0.070	0.076
Total P T	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.009	0.010	0.011	0.012	0.013

Organic waste is normally characterised by five main parameters. These are selected because they encompass the four main aspects of the environmental impact that organic wastes create, namely:-

- The demand for oxygen for the process of aerobic waste breakdown, by which waste is assimilated to its most oxidised state.

- The main impacting constituents of organic waste.

These four parameters are:-

4.2.1. Biochemical Oxidation Demand; BOD

The environmental impact of an organic load can be expressed as the amount of oxygen by weight required by aerobic organisms to completely assimilate a waste into the environment. Simply, complete assimilation means the total oxidation (combination with oxygen) of all the elements contained in both soluble and insoluble organic waste, primarily the carbon, hydrogen and oxygen (C, H, O) found in carbohydrates and fats and these three plus nitrogen, as found in proteins, to their most oxidised form. Small amounts of phosphorus, sulphur and other elements are also found in organic combination, for example in feed proteins which also demand oxygen for their assimilation. The most oxidised forms of the most important elements are:-

- Carbon dioxide (CO_2) and carbonate salts, containing the ion CO_3^-, from the oxidation of the carbon in carbohydrate, fat and protein molecules in the waste.
- Water (H_2O) from the oxidation of hydrogen in carbohydrate, fat and protein molecules in the waste.
- Nitrate salts, containing the nitrate ion (NO_3^-), from the oxidation of nitrogen in protein molecules and in the excretory end-products of protein metabolism, which are ammonia and urea in the case of fish.
- Phosphate salts, containing the orthophosphate ion (PO_4^-) from the oxidation of organic phosphates, or present as a result of the addition of inorganic phosphates to fish rations.

These oxidative processes, known collectively as aerobiosis, take place in the metabolism of all aerobic organisms involved in the assimilation of the waste, including fish, plankton and bacteria in the water column and flora (seaweeds), fauna and bacteria on and in the seabed.

The primary threat in the production of excessive wastes in salmonid farming is to the seabed, where wastes may accumulate, rather than disperse, subject to farm characteristics and management and local hydrographic conditions. With heavy accumulation, oxygen availability is likely to become insufficient to supply the biological oxidation demand of such overloads. This leaves the accumulated wastes and nearby sediments depleted in oxygen. Other types of bacteria, known as *anaerobes*, then multiply and metabolise organic waste by combination with hydrogen, known as *reduction*, rather than by oxygenation. The reduced end products of *anaerobiosis* are more toxic to the environment than oxidised wastes and also have a greater BOD. Such deposits under salmon farms can even be toxic to the salmon that produced the waste in the first place. Signs of overload and anaerobiosis on the seabed under salmon farms, used in the assessment of environmental impact (see Section 2.8) are:-

- Presence of salmon faecal waste and rotting waste salmon feed.
- Blackened sediments, due to the presence of reduced sulphide molecules (as iron sulphide, FeS, which is black), formed by sulphate reducing-bacteria, by anaerobiosis.
- Presence of sulphabacteria (*Beggiatoa sp.*) and rotting waste.
- Out-gassing of hydrogen sulphide gas (H_2S; fully reduced sulphur, originating from waste proteins) and methane (CH_4 fully reduced carbon from carbohydrate, fat and protein waste). These gases are both the toxic products of anaerobic reduction.
- Poor redox levels; redox is a measure of the equilibrium of oxidised to reduced molecules; see Section 2.8. Increasingly negative redox indicates increasing levels of reduced molecules.
- Modified, depleted or absent flora and fauna, on or in the seabed; see also Section 2.8 re ITI, as an indicator of change in infaunal communities due to organic loading.

4.2.2. Total solids discharge and carbon content.

The measure of total solids by weight is a measure of the particulate, insoluble fraction of faeces and feed waste. Assimilation of solids waste requires aerobic bacterial action and thus creates BOD loading.

4.2.3. Nitrogen discharge, N as nitrates.

All forms of nitrogen waste from salmon farms are generally quantified by weight as its most oxidised form, nitrate nitrogen (NO_3N, as nitrate salts). This is because Dissolved Inorganic Nitrogen (DIN) as nitrate N is a limiting nutrient in primary (plant cell) production. As a result, it can have a direct impact on the environment if present in excessive quantities and it is therefore important to quantify it. However, the assimilation of waste N to its most oxidised state, nitrate N also has a BOD requirement.

- Soluble nitrogen waste:-
  Comprises about 90% of total nitrogen waste (where protein digestibility is 90%, as in modern feed protein; see protein digestibly in feed specifications in Table 15). In fish metabolism, the main soluble excretory end products of protein breakdown are ammonia and urea. Once excreted, these end products are then drawn into the nitrogen cycle, through which they are oxidised, in aerobic conditions, into nitrate salts.

- Insoluble nitrogen waste:-
  About 10% of nitrogen waste (where protein digestibility is 90%) is part of the solids fraction of the waste, in the faeces, derived from the elements of feed protein. Insoluble nitrogen waste includes the nitrogen in waste feed.

4.2.4. Phosphorus discharge; P as orthophosphates

As with nitrogen, all phosphorus wastes are quantified by weight in its most oxidised state, as orthophosphate (PO_4P in the form of phosphate salts), rather than in its excreted or solid waste forms. This is because orthophosphate N is a limiting nutrient in primary (plant cell) production in particular in freshwater and in poorly flushed marine and transitional (brackish) water systems . As a result, phosphate can have a direct environmental impact if present in excessive quantities and to quantify it is therefore important. However, the assimilation of waste P to its most oxidised state incurs a BOD loading. Fish require phosphorus for bone and phospholipid formation. The main dietary source of organic phosphorus is fishmeal. Inorganic phosphate is added to the ration to make up the requirement. Phosphorus waste arises in both soluble and solid forms, on the basis of the solubility of the phosphorus components in the diet:-

- Soluble phosphorus waste is soluble phosphorus in digested feed, excess to needs, making up about 62% of total phosphorus waste.

- Insoluble phosphorus waste in the ration is egested in the faeces and makes up about 38% of total phosphorus waste.

4.3. Calculating and projecting impact.

FCR, growth and organic loading are related arithmetically. Thus BOD, SS, N and P can be calculated using formulae in which FCR is a common factor. These formulae enable the calculation of waste parameters per tonne of salmon biogain (increase in weight). They have been used to generate the waste budget spreadsheets and graphs in Tables 17 to 21 and Figures 76 to 78. Digestibility data for whole salmon ration and protein content, required for the equations below are given in Table 17[34]:-

4.3.1. Combined BOD of all wastes:-

The equation given below describes a trend line through scatter plots of empirical data for the BOD of wastes produced by freshwater-farmed rainbow trout. This comes from studies carried out in 1988 by the Danish Department of the Environment. Its use to estimate total BOD is justified here because, as far as is known, it is only the work on salmonids that provides a means of calculating BOD :-

$$\text{BOD pm} = \text{Biogain pm} \times [686 - [(1671 \times \text{FCR})] + [1544 \times \text{FCR2})] - [354 \times (\text{FCR3})]]$$

4.3.2. Solids

The equations given below for faeces and wasted feed solids, are as proposed by Cromey et al (2002)[35]. The calculations for settled faecal solids and waste feed have been modified to assume that the rations contain a standard 5% moisture and that 3% of the total feed supplied to the fish is wasted to the water column and seabed:-

$$\text{Total waste solids} = \text{faeces} + \text{waste feed}$$

$$\text{Faeces (dry wt pm)} = \text{feed pm} \times (1\text{-}0.03) \times (1 - \text{digestibility}) \times (1 - 0.05)$$

$$\text{Waste feed (dry wt pm)} = \text{feed wt pm (tonnes)} \times (1\text{-}0.5) \times 0.03$$

34 Note pm = per month. Units to be applied; g, kg or tonnes to the equations and models as required.

35 Cromey C.J., Nickell T.D., Black K.D. 2002. Depomod; modelling the deposition and biological effects of waste solids from marine cage farms. Aquaculture **214**, 211-239.

4.3.3. Organic carbon

The estimation of organic carbon settlement from the fish farm sites is an important consideration because it is used in the calculation of the *benthic impact index*, in the Scottish Executive's Locational Guidelines for fish farming (2002)[36]. This document offers equations for the calculation of carbon settlement, from both waste feed and faeces, which in turn are used for the modelling of solids wastes dispersal and AZE[37] calculation in Section 4.8. However the formulae used are dependent on quite old data, relating to the carbon content of fish feeds prior to 1990, originating from the work of Gowen et al (1987)[38]. These estimate the carbon content of salmon feeds at 44% and apportion 30% of consumed carbon to faeces, which suggests a ration digestibility of 70%. Whilst it is likely that the carbon content of modern rations differs from Gowen's 1987 estimate (it is probably higher because of the increase in feed oil content, relative to protein), there is no better figure currently available, since, it seems, the study has yet to be repeated on modern rations. Therefore, whilst assumptions regarding digestibility and waste have been modified to reflect the characteristics of modern rations, Gowen's estimate of 44% carbon is used. This allows a wide margin for error in organic carbon deposition calculations. The revised formulae use for suspended / settleable solids are as follows:-

Faecal C pm = Feed pm x (1-digestibility) x (1-0.03) x (1-0.05) x 0.44

Settled waste feed C pm) = Feed pm x (1-0.05) x 0.03 x 0.44

4.3.4. Nitrogen

Nitrogen is mainly present as approximately 16% by weight of salmon feed protein (calculated as feed weight x 0.16). In estimating the waste arising from nitrogen metabolism, the retention of nitrogen from ingested feeds is estimated on the basis that whole salmon contain approximately 3.4% nitrogen (Ackefors and Ennell, 1990[39]). The calculation of total nitrogen discharge is derived from the feed conversion rate, the monthly feed nitrogen content, less the retention, whilst solids (insoluble) and soluble fractions are derived by taking

36 Gillibrand PA, Gubbins MJ, Greathead C and Davies IM. 2002. Scottish Executive locational guidelines for fish farming: predicted levels of nutrient enhancement and benthic impact. Scottish Fisheries Research Report 63

37 AZE; Acceptable Zone of Effect; see again footnote 22 and Section 4.8.

38 Gowen, R.J. and Bradbury, N.B. 1987. The ecological impact of salmonid farming in coastal waters: a review. *Oceanog. Mar. Biol. Ann. Rev*., **25**, 563-575.

39 Ackefors, H. and Enell M. 1990. Discharge of nutrients from Swedish fish farming to adjacent sea areas. Ambio, **19(1)**, 28-35.

account of the digestibility of the protein fraction of the diet. Dietary moisture (5%) and waste feed (3%) versus consumed feed (97%) are also taken account of in the equations:-

$$N0_3N \text{ total pm} = [0.97 \times \text{Biogain pm} \times (\text{ration protein\%} \times 0.16) \times FCR \times 10) - 34] + [0.03 \times (\text{ration protein pm} \times 0.16)]$$

$$N0_3N \text{ soluble pm} = N0_3N \text{ total pm} \times \text{protein digestibility.}$$

$$N0_3N \text{ insoluble pm} = N0_3N \text{ total pm} \times (1 - \text{protein digestibility})$$

4.3.5. Phosphorus

The equations for phosphorus waste are similar to those for nitrogen but assume a solubility of 62% and a retention salmon flesh of 0.5%.

$$P0_3P \text{ total pm} = [0.97 \times \text{Biogain pm} \times \text{ration P\%} \times FCR \times 10) - 5] + [.03 \times \text{ration P pm}]$$

$$PO_4P \text{ soluble pm} = PO_4P \text{ total pm} \times \text{digestibility.}$$

$$PO_4P \text{ insoluble pm} = PO_4P \text{ total pm} \times (1\text{-digestibility})$$

In Figure 75, the formulae above have been used to calculate BOD, solids, total carbon, total NO_3N and total PO_4P discharges per tonne of salmon biogain for an FCR range from 0.8 to 2.0 (that is an FCR 0.8 tonnes wet weight of salmon produced from one tonne dry weight of salmon feed fed, to an FCR of one tonne wet weight of salmon produced per two tonnes dry weight salmon feed fed). This shows that the waste generated for each tonne of salmon produced reduces with decreasing FCR (that is with increasing feed and feed application efficiency).

Modern salmon farming aims to optimise the balance between cost effective fish growth and minimal waste production. Feed manufacturers and fish nutritionists have made considerable progress towards these objectives in the last decade, with the formulation and manufacture of more cost effective, higher digestibility feeds, with resultant higher nutritional value per unit cost of growth. These advantages have been improved upon by the introduction of improved feeding systems and on-site feed management, underpinning the environmental sustainability of salmon farming salmon as well as overall unit production cost, as the following sections seek to demonstrate.

4.4. Discharge budgeting for the proposed Shot Head site.

Discharge budgeting is a means of predicting organic waste production from a specified fish farming unit on a temporal basis, using growth, FCR data and manufacturer's information on feed digestibility and composition. The formulae given in Section 4.3 are used for this purpose, along with the growth model spreadsheets, derived from actual MHI data, given in Tables 15 and 16.

Tables 17 and 18 estimate monthly feed usage and feed composition using BioMar Ecolife Pearl organic rations. Table 19 then gives the resulting discharge budget for the Shot Head site, projecting full, steady state production (from October 2011 earliest), using the formulae given for the basket of discharge parameters described in Section 4.3.

Figure 76 graphs the relevant outputs from Tables 15 to 18 to show projected monthly growth and harvest statistics in Figures 76.1 to 76.3, projected monthly total BOD of discharges in Figure 76.4, monthly solids and carbon discharges in Figures 76.5 and 76.6 and monthly settleable and soluble nutrient discharges in Figures 76.7 and 76.8. Note that Table 22.1 summarises all discharge data for all scenarios discussed for the proposed Shot Head site on an annualised basis whilst Table 23.1 summarises the data on a per tonne salmon growth basis.

Overall, Figure 76 shows that growth and discharge parameters increase monthly, from input until the peak site standing stock of 2,800 tonnes is reached, at which point which point harvesting commences, in March in alternate years. The growth of the fish remaining in the cages continues for some months until the peak harvest mean weight of 5,600g is reached and the balance of the fish are harvested from the system. All discharge parameters decrease steadily once harvest has commenced, as the total number of fish and standing stock decrease, to reach zero, at the end of the harvesting period. The next cycle commences, after the fallowing period, when the cages are empty. There are no discharges from the site during the fallowing period.

The site is expected to lie fallow for a minimum of two months, from mid to late-September biennially, following the completion of harvest, until it is restocked some two months later, around mid-November. It is material that the fallowing period occurs over the winter months because this is when the site is at its most hydro-active, leading to relatively rapid dispersal of any solids that may have accumulated under the cages during the production cycle, allowing the site sufficient time to rejuvenate, before the commencement of next cycle.

Table 17.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Feed specifications; Biomar Ecolife Pearl Organic salmon ration (compare to CPK standard ration)

Feed detail non-organic	Pellet size mm	Mean weight range g	Gross energy MJ/kg	Digestible energy MJ/kg	Thus Digestibility %	Oil %	Protein %	Phos-phorus %	Digestible protein %	Thus % protein digestibility	Potential FCR	Carbo-hydrate %	NFE %	Ash %	Moisture %
MHI Ireland Biomar CPK standard ration (non-organic)															
CPK 2mm	2.0	15-50	22.6	18.5	81.86	23	49.0	1.0	43.4	88.57	0.70	13.00	11.00	9.00	5.00
CPK 3mm	3.0	50-150	22.6	18.5	81.86	24	46.0	1.0	39.8	86.52	0.70	15.00	12.00	9.00	5.00
CPK 4.5mm	4.5	150-500	23	18.8	81.74	26	43.0	1.0	38.0	88.37	0.78	16.50	14.50	8.50	5.00
CPK 6.5mm	6.5	500-1000	24.1	19.5	80.91	30	40.0	0.9	34.5	86.25	0.85	15.00	13.00	8.00	5.00
E33/38 9mm	9.0	1000-2000	25.2	20.3	80.56	33	38.0	0.9	32.0	84.21	0.95	16.00	13.00	7.00	5.00
E33/38 12mm	12.0	2000-	25.2	20.3	80.56	33	38.0	0.9	32.0	84.21	1.05	16.00	13.00	7.00	5.00

Feed detail organic	Pellet size mm	Mean weight range g	Gross energy MJ/kg	Digestible energy MJ/kg	Thus feed digestibility %	Oil %	Protein %	Phos-phorus %	Digestible protein %	Thus % protein digestibility	Potential FCR	Carbo-hydrate %	NFE %	Ash %	Moisture %
MHI Ireland Biomar EcoLife Pearl organic ration															
Pearl 2mm	2.0	15-50	22.2	18.5	83.33	22	46.0	1.0	40.4	87.83	0.70	14.00	12.00	11.00	5.00
Pearl 3mm	3.0	50-150	22.2	18.5	83.33	22	46.0	1.0	40.4	87.83	0.70	14.00	12.00	11.00	5.00
Pearl 4.5mm	4.5	150-500	22.7	18.8	82.82	24	44.0	1.0	38.2	86.82	0.78	14.00	12.00	10.00	5.00
Pearl 6.5mm	6.5	500-1000	23.3	19.2	82.40	26	42.0	0.9	36.1	85.95	0.80	16.00	14.00	9.00	5.00
Pearl 9mm	9.0	1000-2000	24.1	20.2	83.82	32.5	37.9	0.9	34.4	90.77	0.98	17.00	14.00	8.50	5.00
Pearl 12mm	12.0	2000-	24.1	20.2	83.82	32.5	37.9	0.9	34.4	90.77	1.05	17.00	14.00	8.50	5.00

Table 18.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Projected feed requirements and specifications, calculated from growth and feed data in Table 16.

Month	Biogain	Fish mw g	Feed specification					Feed / nutrients Tonnes / month					Digestibilty %		Month
ending	Tonnes	month end	Type	Size mm	Protein %	Oil %	Phos. %	FCR	Feed	Protein	NO_3 N	PO_3 P	Total feed	Protein	ending
Nov	19.62	101	Pearl	3.0	46.0	22.0	1.0	0.95	18.64	8.57	1.37	0.19	83.33	87.83	Nov
Dec	30.88	141	Pearl	3.0	46.0	22.0	1.0	0.95	29.33	13.49	2.16	0.29	83.33	87.83	Dec
Jan	44.49	198	Pearl	4.5	44.0	24.0	1.0	1.00	44.49	19.57	3.13	0.44	82.82	86.82	Jan
Feb	60.22	275	Pearl	4.5	44.0	24.0	1.0	1.10	66.25	29.15	4.66	0.66	82.82	86.82	Feb
Mar	77.75	375	Pearl	4.5	44.0	24.0	1.0	1.20	93.30	41.05	6.57	0.93	82.82	86.82	Mar
Apr	100.50	505	Pearl	4.5	44.0	24.0	1.0	1.20	120.60	53.06	8.49	1.21	82.82	86.82	Apr
May	124.70	670	Pearl	6.5	42.0	26.0	0.9	1.23	152.76	64.16	10.27	1.37	82.40	85.95	May
Jun	155.04	880	Pearl	6.5	42.0	26.0	0.9	1.25	193.80	81.40	13.02	1.74	82.40	85.95	Jun
Jul	179.00	1,130	Pearl	6.5	42.0	26.0	0.9	1.27	227.33	95.48	15.28	2.05	82.40	85.95	Jul
Aug	192.47	1,417	Pearl	9.0	37.9	32.5	0.9	1.27	244.44	92.64	14.82	2.20	83.82	90.77	Aug
Sep	219.22	1,745	Pearl	9.0	37.9	32.5	0.9	1.27	278.41	105.52	16.88	2.51	83.82	90.77	Sep
Oct	262.96	2,120	Pearl	9.0	37.9	32.5	0.9	1.27	333.96	126.57	20.25	3.01	83.82	90.77	Oct
Nov	288.16	2,550	Pearl	12.0	37.9	32.5	0.9	1.27	365.96	138.70	22.19	3.29	83.82	90.77	Nov
Dec	321.34	3,025	Pearl	12.0	37.9	32.5	0.9	1.27	408.10	154.67	24.75	3.67	83.82	90.77	Dec
Jan	346.65	3,540	Pearl	12.0	37.9	32.5	0.9	1.27	440.24	166.85	26.70	3.96	83.82	90.77	Jan
Feb	314.27	4,036	Pearl	12.0	37.9	32.5	0.9	1.27	399.12	151.27	24.20	3.59	83.82	90.77	Feb
Mar	304.85	4,534	Pearl	12.0	37.9	32.5	0.9	1.27	387.16	146.73	23.48	3.48	83.82	90.77	Mar
Apr	207.89	4,975	Pearl	12.0	37.9	32.5	0.9	1.27	264.02	100.06	16.01	2.38	83.82	90.77	Apr
May	110.15	5,248	Pearl	12.0	37.9	32.5	0.9	1.27	139.89	53.02	8.48	1.26	83.82	90.77	May
Jun	44.88	5,420	Pearl	12.0	37.9	32.5	0.9	1.27	57.00	21.60	3.46	0.51	83.82	90.77	Jun
Jul	28.28	5,544	Pearl	12.0	37.9	32.5	0.9	1.27	35.92	13.61	2.18	0.32	83.82	90.77	Jul
Aug	3.99	5,600	Pearl	12.0	37.9	32.5	0.9	1.27	5.06	1.92	0.31	0.05	83.82	90.77	Aug
Sep	0.00	0	Pearl	12.0	37.9	32.5	0.9	0.00	0.00	0.00	0.00	0.00	83.82	90.77	Sep
Oct	0.00	0	Pearl	12.0	37.9	32.5	0.9	0.00	0.00	0.00	0.00	0.00	83.82	90.77	Oct

Table 19.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Projected multigeneration soluble nutrient and solids discharge budget. Shot Head only.
Notes
1. Model uses Biomar Ecolife Pearl organic ration; see Tables 15 and 16.

Key: Peak monthly discharges by site

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Shot Head site discharge budget years 1 to 6.												
Year	Month ending	BOD_5 Tonnes pm	Solids			Settleable carbon			Nitrogen discharge T / month			Phosphorus discharge T / month		
			Feed waste Tonnes pm	Faeces Tonnes pm	Total solids Tonnes pm	Feed waste C T pm	Faecal C Tonnes pm	Total C T pm	Settleable N T pm	Soluble N Tonnes pm	Total N Tonnes pm	Settleable P T pm	Soluble P Tonnes pm	Total P Tonnes pm
1	Nov	3.70	0.53	2.86	3.39	0.23	1.26	1.49	0.09	0.64	0.72	0.03	0.06	0.09
1	Dec	5.82	0.84	4.50	5.34	0.37	1.98	2.35	0.14	1.00	1.14	0.05	0.09	0.14
2	Jan	9.12	1.27	7.04	8.31	0.56	3.10	3.66	0.22	1.45	1.66	0.09	0.14	0.23
2	Feb	14.75	1.89	10.49	12.38	0.83	8.06	8.89	0.35	2.32	2.68	0.14	0.23	0.37
2	Mar	22.74	2.66	14.77	17.43	1.17	11.35	12.52	0.53	3.48	4.00	0.21	0.34	0.56
2	Apr	29.39	3.44	19.09	22.53	1.51	14.67	16.18	0.68	4.49	5.18	0.27	0.45	0.72
2	May	38.07	4.35	24.77	29.12	1.92	18.58	20.50	0.86	5.29	6.15	0.29	0.48	0.77
2	Jun	49.36	5.52	31.43	36.95	2.43	23.57	26.00	1.11	6.80	7.91	0.38	0.62	0.99
2	Jul	58.89	6.48	36.86	43.34	2.85	27.65	30.50	1.32	8.06	9.37	0.45	0.73	1.18
2	Aug	63.33	6.97	36.45	43.42	3.07	29.73	32.80	0.78	7.69	8.48	0.48	0.79	1.27
2	Sep	72.13	7.93	41.52	49.45	3.49	33.87	37.36	0.89	8.76	9.65	0.55	0.89	1.44
2	Oct	86.52	9.52	49.80	59.32	4.19	40.62	44.81	1.07	10.51	11.58	0.66	1.07	1.73
2	Nov	94.81	10.43	54.57	65.00	4.59	44.52	49.10	1.17	11.52	12.69	0.72	1.18	1.90
2	Dec	105.73	11.63	60.86	72.49	5.12	49.64	54.76	1.31	12.84	14.15	0.80	1.31	2.11
3	Jan	114.05	12.55	65.65	78.20	5.52	53.55	59.07	1.41	13.85	15.26	0.87	1.41	2.28
3	Feb	103.40	11.38	59.52	70.89	5.01	48.55	53.55	1.28	12.56	13.84	0.79	1.28	2.07
3	Mar	100.30	11.03	57.73	68.77	4.85	47.09	51.95	1.24	12.18	13.42	0.76	1.24	2.01
3	Apr	68.40	7.52	39.37	46.90	3.31	32.11	35.43	0.85	8.31	9.15	0.52	0.85	1.37
3	May	36.24	3.99	20.86	24.85	1.75	17.02	18.77	0.45	4.40	4.85	0.28	0.45	0.72
3	Jun	14.77	1.62	8.50	10.12	0.71	6.93	7.65	0.18	1.79	1.98	0.11	0.18	0.30
3	Jul	9.31	1.02	5.36	6.38	0.45	4.37	4.82	0.12	1.13	1.25	0.07	0.12	0.19
3	Aug	1.31	0.14	0.75	0.90	0.06	0.62	0.68	0.02	0.16	0.18	0.01	0.02	0.03
3	Sep	No discharges; Shot Head site fallow												
3	Oct													
3	Nov	3.70	0.53	2.86	3.39	0.23	1.26	1.49	0.09	0.64	0.72	0.03	0.06	0.09
3	Dec	5.82	0.84	4.50	5.34	0.37	1.98	2.35	0.14	1.00	1.14	0.05	0.09	0.14
4	Jan	9.12	1.27	7.04	8.31	0.56	3.10	3.66	0.22	1.45	1.66	0.09	0.14	0.23
4	Feb	14.75	1.89	10.49	12.38	0.83	8.06	8.89	0.35	2.32	2.68	0.14	0.23	0.37
4	Mar	22.74	2.66	14.77	17.43	1.17	11.35	12.52	0.53	3.48	4.00	0.21	0.34	0.56
4	Apr	29.39	3.44	19.09	22.53	1.51	14.67	16.18	0.68	4.49	5.18	0.27	0.45	0.72
4	May	38.07	4.35	24.77	29.12	1.92	18.58	20.50	0.86	5.29	6.15	0.29	0.48	0.77
4	Jun	49.36	5.52	31.43	36.95	2.43	23.57	26.00	1.11	6.80	7.91	0.38	0.62	0.99
4	Jul	58.89	6.48	36.86	43.34	2.85	27.65	30.50	1.32	8.06	9.37	0.45	0.73	1.18
4	Aug	63.33	6.97	36.45	43.42	3.07	29.73	32.80	0.78	7.69	8.48	0.48	0.79	1.27
4	Sep	72.13	7.93	41.52	49.45	3.49	33.87	37.36	0.89	8.76	9.65	0.55	0.89	1.44
4	Oct	86.52	9.52	49.80	59.32	4.19	40.62	44.81	1.07	10.51	11.58	0.66	1.07	1.73
4	Nov	94.81	10.43	54.57	65.00	4.59	44.52	49.10	1.17	11.52	12.69	0.72	1.18	1.90
4	Dec	105.73	11.63	60.86	72.49	5.12	49.64	54.76	1.31	12.84	14.15	0.80	1.31	2.11
5	Jan	114.05	12.55	65.65	78.20	5.52	53.55	59.07	1.41	13.85	15.26	0.87	1.41	2.28
5	Feb	103.40	11.38	59.52	70.89	5.01	48.55	53.55	1.28	12.56	13.84	0.79	1.28	2.07
5	Mar	100.30	11.03	57.73	68.77	4.85	47.09	51.95	1.24	12.18	13.42	0.76	1.24	2.01
5	Apr	68.40	7.52	39.37	46.90	3.31	32.11	35.43	0.85	8.31	9.15	0.52	0.85	1.37
5	May	36.24	3.99	20.86	24.85	1.75	17.02	18.77	0.45	4.40	4.85	0.28	0.45	0.72
5	Jun	14.77	1.62	8.50	10.12	0.71	6.93	7.65	0.18	1.79	1.98	0.11	0.18	0.30
5	Jul	9.31	1.02	5.36	6.38	0.45	4.37	4.82	0.12	1.13	1.25	0.07	0.12	0.19
5	Aug	1.31	0.14	0.75	0.90	0.06	0.62	0.68	0.02	0.16	0.18	0.01	0.02	0.03
5	Sep	No discharges; Shot Head site fallow												
5	Oct													
5	Nov	3.70	0.53	2.86	3.39	0.23	1.26	1.49	0.09	0.64	0.72	0.03	0.06	0.09
5	Dec	5.82	0.84	4.50	5.34	0.37	1.98	2.35	0.14	1.00	1.14	0.05	0.09	0.14
6	Jan	9.12	1.27	7.04	8.31	0.56	3.10	3.66	0.22	1.45	1.66	0.09	0.14	0.23
6	Feb	14.75	1.89	10.49	12.38	0.83	8.06	8.89	0.35	2.32	2.68	0.14	0.23	0.37
6	Mar	22.74	2.66	14.77	17.43	1.17	11.35	12.52	0.53	3.48	4.00	0.21	0.34	0.56
6	Apr	29.39	3.44	19.09	22.53	1.51	14.67	16.18	0.68	4.49	5.18	0.27	0.45	0.72
6	May	38.07	4.35	24.77	29.12	1.92	18.58	20.50	0.86	5.29	6.15	0.29	0.48	0.77
6	Jun	49.36	5.52	31.43	36.95	2.43	23.57	26.00	1.11	6.80	7.91	0.38	0.62	0.99
6	Jul	58.89	6.48	36.86	43.34	2.85	27.65	30.50	1.32	8.06	9.37	0.45	0.73	1.18
6	Aug	63.33	6.97	36.45	43.42	3.07	29.73	32.80	0.78	7.69	8.48	0.48	0.79	1.27
6	Sep	72.13	7.93	41.52	49.45	3.49	33.87	37.36	0.89	8.76	9.65	0.55	0.89	1.44
6	Oct	86.52	9.52	49.80	59.32	4.19	40.62	44.81	1.07	10.51	11.58	0.66	1.07	1.73
6	Nov	94.81	10.43	54.57	65.00	4.59	44.52	49.10	1.17	11.52	12.69	0.72	1.18	1.90
6	Dec	105.73	11.63	60.86	72.49	5.12	49.64	54.76	1.31	12.84	14.15	0.80	1.31	2.11
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Figure 76.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Shot Head; projections of main farm and discharge parameters over four cycles (8 years).
Note changing vertical axis.

Figure 76.1. Fish mean weight kg.

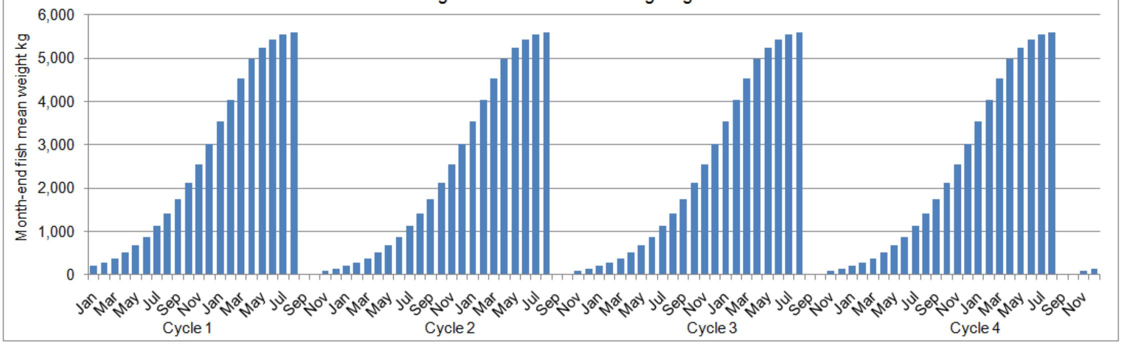


Figure 76.2. Monthly biogain (growth) and feed tonnes.

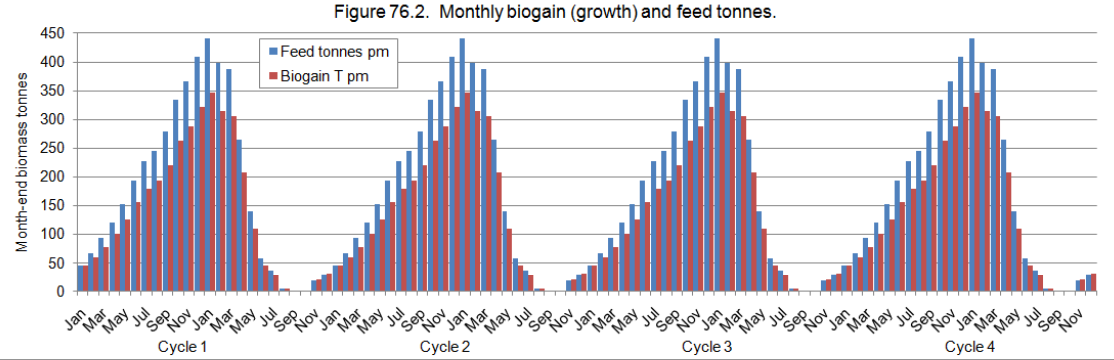


Figure 76.3. Monthly standing stock and harvest tonnes.

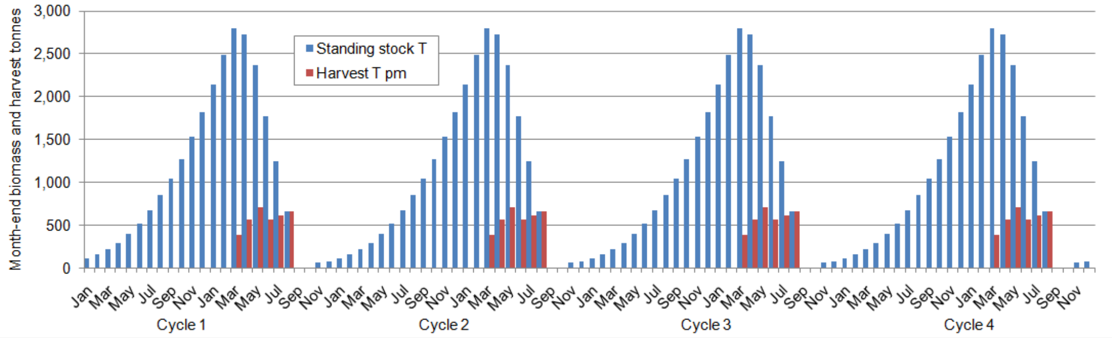


Figure 76.4. Total BOD of waste discharges tonnes per month.

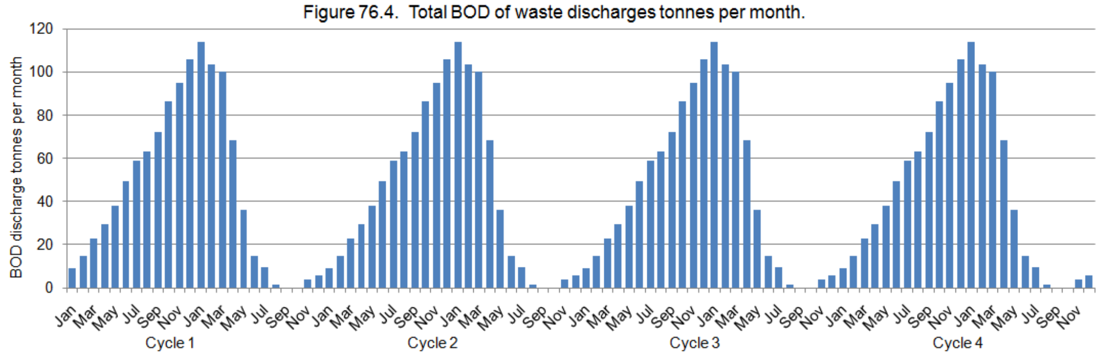


Figure 76 continued.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Shot Head; projections of main farm and discharge parameters over four cycles (8 years).
Note changing vertical axis.

Figure 76.3. Total solids discharges tonnes per month.

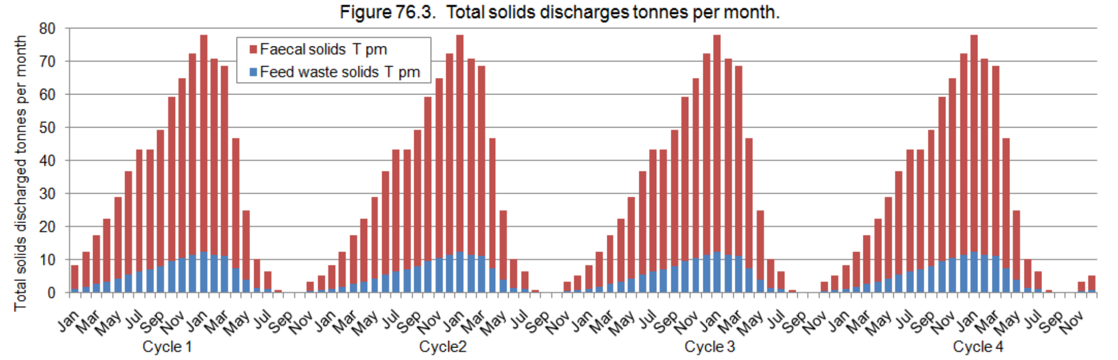


Figure 76.6. Total carbon discharges tonnes per month.

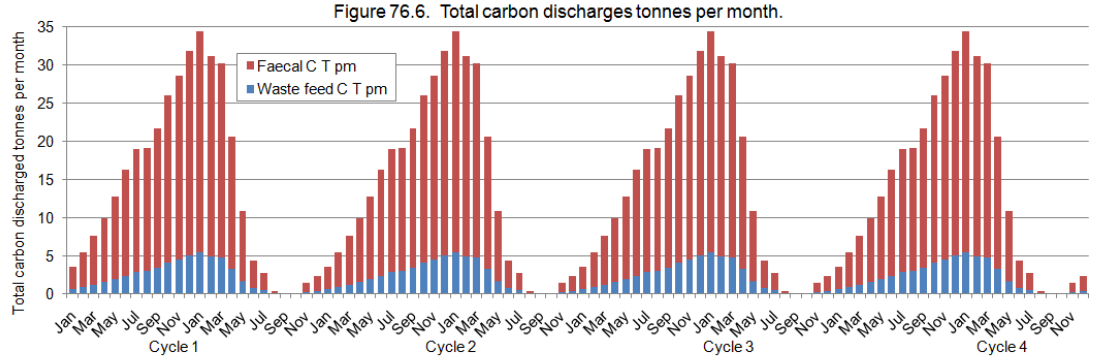


Figure 76.7. Total nitrogen discharges tonnes per month.

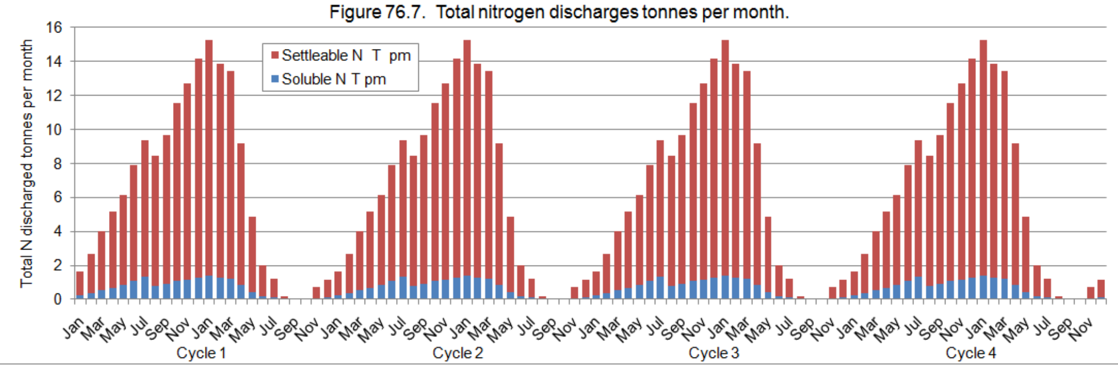
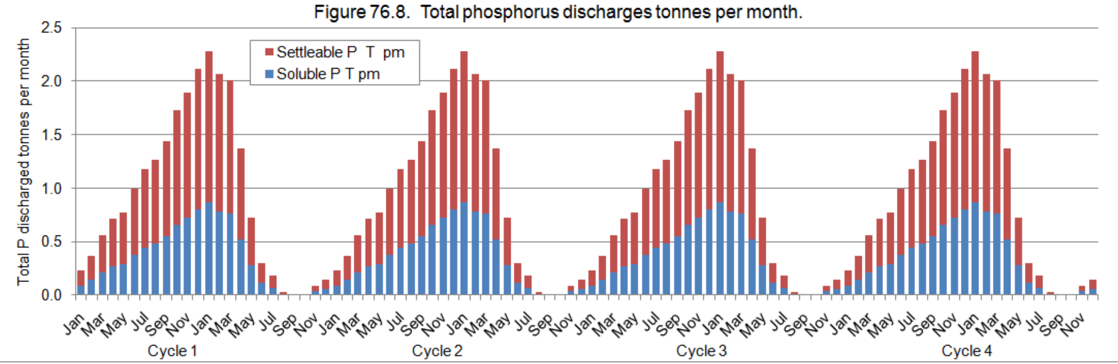


Figure 76.8. Total phosphorus discharges tonnes per month.



Further issues that to be considered in the context of discharge budgeting are:-

- The combined discharges from all salmon farm sites in Bantry Bay.
- Identification of the likely worst case discharge scenario, which is likely to arise from the combined discharges of all salmon farm sites in Bantry Bay
- Estimation of worst case scenarios for the dispersal, dilution and assimilation of combined discharges from all salmon farm sites in the bay.

These issues are dealt with in the following sections.

4.5. Combined soluble discharges from MHI farm sites in Bantry Bay.

As described in Section 3, the initial intention for the proposed Shot Head site, if licensed, is to stock it in annual alternation with MHI Roancarrig, such that harvests of 3,500 tonnes are taken in alternate years from the two sites. Since the sites' production cycles will alternate biennially, their stock statistics and discharges will also alternate in a similar manner. This is expressed in Table 20 and Figure 77. The same data are summarised on an annualised basis in Tables 22.2 and 23.2 which show that the combined discharges from the MHI sites (licensed and proposed), will comprise:-

- 1,110 tonnes pa of BOD, with a combined site monthly peak of 123.17 tonnes BOD each January. The bulk of BOD is required for the oxidation and assimilation of:-
- 775 tonnes pa of faecal and food waste solids, containing 341 tonnes of carbon, with monthly peaks of 86 tonnes of solids and 38 tonnes of carbon respectively, each January.
- 157 tonnes total N of which 141 tonnes is soluble and 16 tonnes settleable; total N monthly peak occurs each March at 17.4 tonnes.
- 23 tonnes pa tonnes total P, of which 14 tonnes is soluble and 9 tonnes is settleable; the total P monthly peak occurs each March at 2.6 tonnes.

These discharges arise from the metabolic processes involved in the production of 3,484 tonnes per annum of salmon growth (biogain) between alternating production at the two sites and the combined consumption of 4,349 tonnes of feed pa (see Tables 20 and 22.2). These figures will be modified if the sites are operated synchronously as summarised in Table 23.2.

Table 20.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Selected main farm and discharge data; MHI Shot Head (proposed) and MHI Roancarrig combined.

Notes

1. Model uses Biomar Ecolife Pearl organic ration; see Tables 15 and 16.

Key: (green shading) Peak monthly discharges by site

		Shot Head discharge budget years 1 - 4								MHI Roancarrig discharge budget years 1 - 4							
				Nitrogen discharge T / month			Phosphorus discharge T / month					Nitrogen discharge T / month			Phosphorus discharge T / month		
Year	Month ending	Standing stock T	Biogain T pm	Settleable N T pm	Soluble N T pm	Total N T pm	Settleable P T pm	Soluble P T pm	Total P T pm	Standing stock T	Biogain T pm	Settleable N T pm	Soluble N T pm	Total N T pm	Settleable P T pm	Soluble P T pm	Total P T pm
1	Nov	63	19.62	0.09	0.64	0.72	0.03	0.06	0.09	1,530	288.16	1.17	11.52	12.69	0.72	1.18	1.90
1	Dec	82	30.88	0.14	1.00	1.14	0.05	0.09	0.14	1,818	321.34	1.31	12.84	14.15	0.80	1.31	2.11
2	Jan	113	44.49	0.22	1.45	1.66	0.09	0.14	0.23	2,139	346.65	1.41	13.85	15.26	0.87	1.41	2.28
2	Feb	158	60.22	0.35	2.32	2.68	0.14	0.23	0.37	2,486	314.27	1.28	12.56	13.84	0.79	1.28	2.07
2	Mar	218	77.75	0.53	3.48	4.00	0.21	0.34	0.56	2,800	304.85	1.24	12.18	13.42	0.76	1.24	2.01
2	Apr	296	100.50	0.68	4.49	5.18	0.27	0.45	0.72	2,722	207.89	0.85	8.31	9.15	0.52	0.85	1.37
2	May	396	124.70	0.86	5.29	6.15	0.29	0.48	0.77	2,366	110.15	0.45	4.40	4.85	0.28	0.45	0.72
2	Jun	521	155.04	1.11	6.80	7.91	0.38	0.62	0.99	1,768	44.88	0.18	1.79	1.98	0.11	0.18	0.30
2	Jul	676	179.00	1.32	8.06	9.37	0.45	0.73	1.18	1,245	28.28	0.12	1.13	1.25	0.07	0.12	0.19
2	Aug	855	192.47	0.78	7.69	8.48	0.48	0.79	1.27	658	3.99	0.02	0.16	0.18	0.01	0.02	0.03
2	Sep	1,047	219.22	0.89	8.76	9.65	0.55	0.89	1.44	End of Roancarrig Cycle 1; no discharges; site fallow before restock for Cycle 2.							
2	Oct	1,267	262.96	1.07	10.51	11.58	0.66	1.07	1.73								
2	Nov	1,530	288.16	1.17	11.52	12.69	0.72	1.18	1.90	63	19.62	0.09	0.64	0.72	0.03	0.06	0.09
2	Dec	1,818	321.34	1.31	12.84	14.15	0.80	1.31	2.11	82	30.88	0.14	1.00	1.14	0.05	0.09	0.14
3	Jan	2,139	346.65	1.41	13.85	15.26	0.87	1.41	2.28	113	44.49	0.22	1.45	1.66	0.09	0.14	0.23
3	Feb	2,486	314.27	1.28	12.56	13.84	0.79	1.28	2.07	158	60.22	0.35	2.32	2.68	0.14	0.23	0.37
3	Mar	2,800	304.85	1.24	12.18	13.42	0.76	1.24	2.01	218	77.75	0.53	3.48	4.00	0.21	0.34	0.56
3	Apr	2,722	207.89	0.85	8.31	9.15	0.52	0.85	1.37	296	100.50	0.68	4.49	5.18	0.27	0.45	0.72
3	May	2,366	110.15	0.45	4.40	4.85	0.28	0.45	0.72	396	124.70	0.86	5.29	6.15	0.29	0.48	0.77
3	Jun	1,768	44.88	0.18	1.79	1.98	0.11	0.18	0.30	521	155.04	1.11	6.80	7.91	0.38	0.62	0.99
3	Jul	1,245	28.28	0.12	1.13	1.25	0.07	0.12	0.19	676	179.00	1.32	8.06	9.37	0.45	0.73	1.18
3	Aug	658	3.99	0.02	0.16	0.18	0.01	0.02	0.03	855	192.47	0.78	7.69	8.48	0.48	0.79	1.27
3	Sep	End of Shot Head Cycle 1; no discharges; site fallow before restock for Cycle 2.								1,047	219.22	0.89	8.76	9.65	0.55	0.89	1.44
3	Oct									1,267	262.96	1.07	10.51	11.58	0.66	1.07	1.73
3	Nov	63	19.62	0.09	0.64	0.72	0.03	0.06	0.09	1,530	288.16	1.17	11.52	12.69	0.72	1.18	1.90
3	Dec	82	30.88	0.14	1.00	1.14	0.05	0.09	0.14	1,818	321.34	1.31	12.84	14.15	0.80	1.31	2.11
4	Jan	113	44.49	0.22	1.45	1.66	0.09	0.14	0.23	2,139	346.65	1.41	13.85	15.26	0.87	1.41	2.28
4	Feb	158	60.22	0.35	2.32	2.68	0.14	0.23	0.37	2,486	314.27	1.28	12.56	13.84	0.79	1.28	2.07
4	Mar	218	77.75	0.53	3.48	4.00	0.21	0.34	0.56	2,800	304.85	1.24	12.18	13.42	0.76	1.24	2.01
4	Apr	296	100.50	0.68	4.49	5.18	0.27	0.45	0.72	2,722	207.89	0.85	8.31	9.15	0.52	0.85	1.37
4	May	396	124.70	0.86	5.29	6.15	0.29	0.48	0.77	2,366	110.15	0.45	4.40	4.85	0.28	0.45	0.72
4	Jun	521	155.04	1.11	6.80	7.91	0.38	0.62	0.99	1,768	44.88	0.18	1.79	1.98	0.11	0.18	0.30
4	Jul	676	179.00	1.32	8.06	9.37	0.45	0.73	1.18	1,245	28.28	0.12	1.13	1.25	0.07	0.12	0.19
4	Aug	855	192.47	0.78	7.69	8.48	0.48	0.79	1.27	658	3.99	0.02	0.16	0.18	0.01	0.02	0.03
4	Sep	1,047	219.22	0.89	8.76	9.65	0.55	0.89	1.44	End of Roancarrig Cycle 2; site fallow before restock for Cycle 3.							
4	Oct	1,267	262.96	1.07	10.51	11.58	0.66	1.07	1.73								
4	Nov	1,530	288.16	1.17	11.52	12.69	0.72	1.18	1.90	63	19.62	0.09	0.64	0.72	0.03	0.06	0.09
4	Dec	1,818	321.34	1.31	12.84	14.15	0.80	1.31	2.11	82	30.88	0.14	1.00	1.14	0.05	0.09	0.14

Figure 77.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Combined main farm and discharge data; MHI Shot Head (proposed) and MHI Roancarrig.
Note changing vertical axis.

Figure 77.1. Roancarrig and Shot Head combined monthly biogain (growth) tonnes.

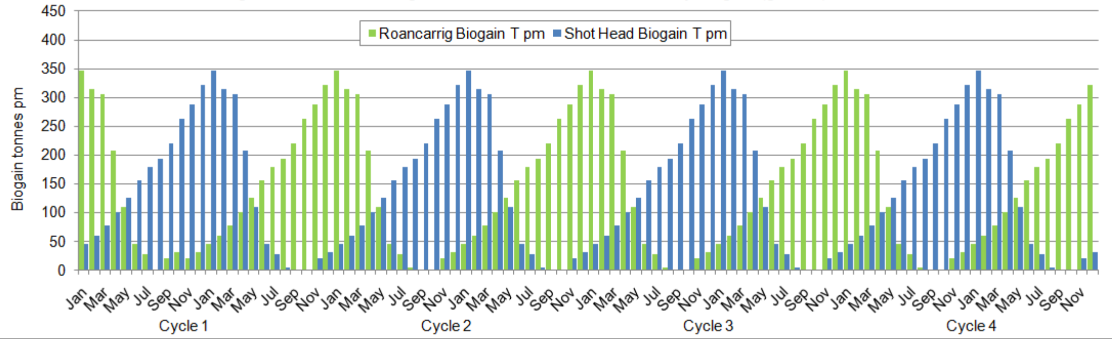


Figure 77.2. Roancarrig and Shot Head combined monthly standing stock tonnes.

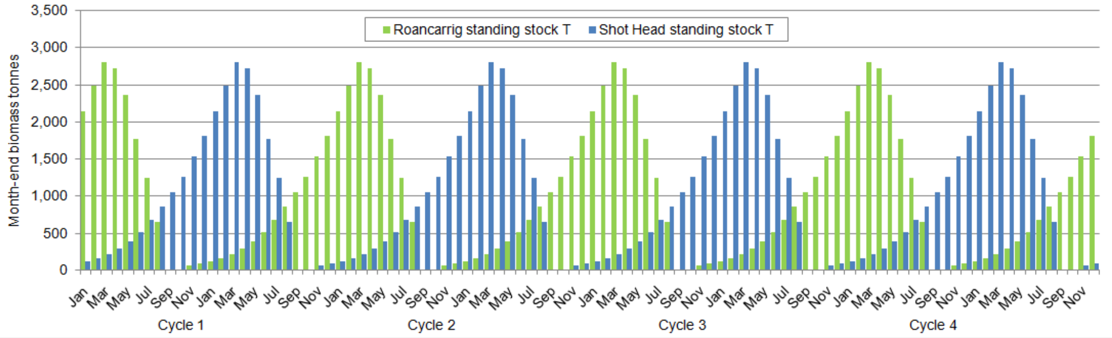


Figure 77.3. Roancarrig and Shot Head combined monthly nitrogen discharge tonnes pm.

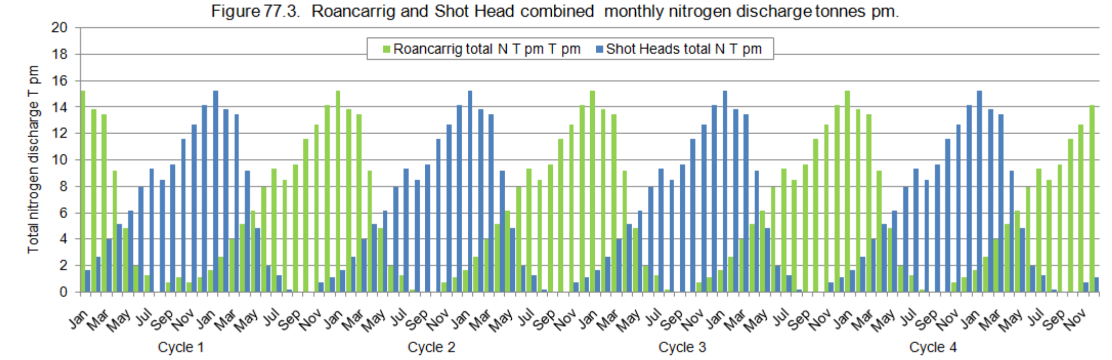
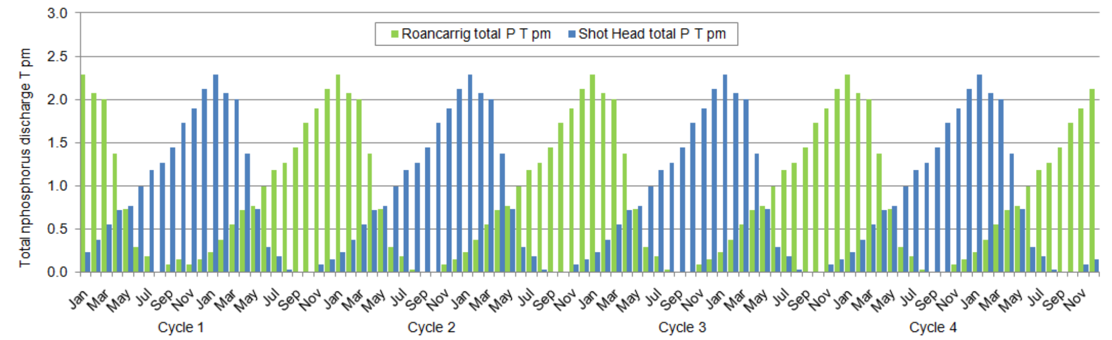


Figure 77.4. Roancarrig and Shot Head combined monthly phosphorus discharge tonnes pm.



4.6. Combined soluble discharges from all salmon farm sites in Bantry Bay.

At present there are four licensed salmon farm sites in Bantry Bay. Two, situated near Roancarrig Rocks, in outer Bantry Bay, are owned by MHI, comprising a smolt site and a grower site. The other two sites, towards the head of the bay, are owned by Fastnet Irish Seafood and also comprise a smolt site and a grower site. The MHI Roancarrig main site centre is some 8km west of the proposed Shot Head site whilst the two Fastnet sites are 5km and 5.5 km SSE of it respectively, on the southern shore of the bay, as shown in Figure 79. The Fastnet sites are currently operated on the "two sites per cycle" production strategy prevalent in Ireland until recent times, as explained in Section 1.3. The Roancarrig sites are licensed to harvest 2,000 tonnes of round salmon per annum whilst the Fastnet sites are licensed to produce 500 tonnes per annum. Both companies produce certified organic salmon on their Bantry Bay sites.

As discussed in Section 3.2, the "worst case", from the point of view of combined discharges, would arise from the implementation of simultaneous smolt transfers, growth, harvesting and fallowing of all the salmon grow out sites in Bantry Bay, in the full spirit of Single Bay Management. This would require the adoption of synchronous two-year growth cycles, with a biennial harvest period by all farms in the bay, as shown in Figures 78.1 to 78.3. The quantities of main discharges that would arise if this strategy were adopted are shown Table 21 and in Figures 78.4 to 78.8. The main production and discharge data are also summarised, along with all other scenarios discussed, on an annualised basis in Table 22.4 and on a per tonne fish growth basis in Table 23.4.

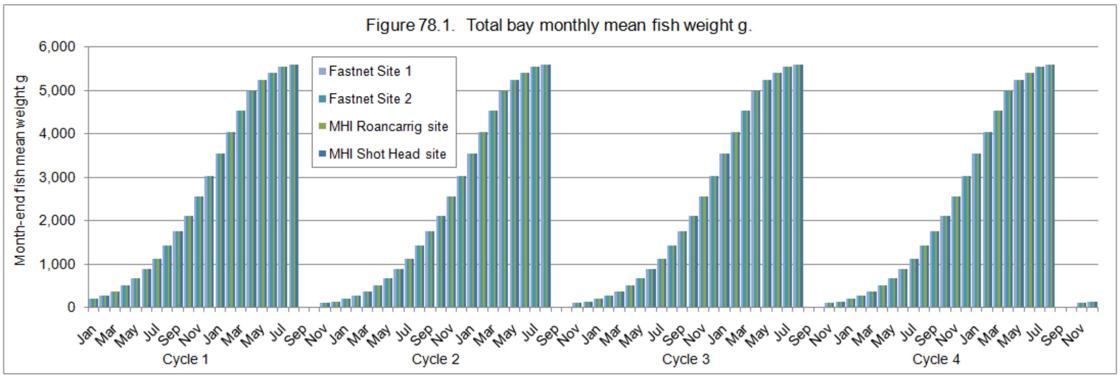
Summary tables 22.2 and 22.3 compare the annual data for alternate and synchronous production for the two MHI sites in Bantry Bay only, enabling a direct comparison of the effects of the two stocking methods (alternate versus synchronous stocking). It is pointed out that, whilst peak standing stock, biogain, feed and all discharges peak at higher levels and trough at lower levels in synchronous production, the discharges per two year cycle period and per tonne growth are identical for both strategies. Figures 23.2 and 23.3 confirm this. Thus, on a cycle by cycle basis, there is no difference between the two strategies in terms of discharges. However what remains to be quantified is the potential impact of the discharge peaks that result from the synchronisation of growth cycles of all the salmon farm sites in the bay. This is investigated in the next section by the use of a tidal prism model.

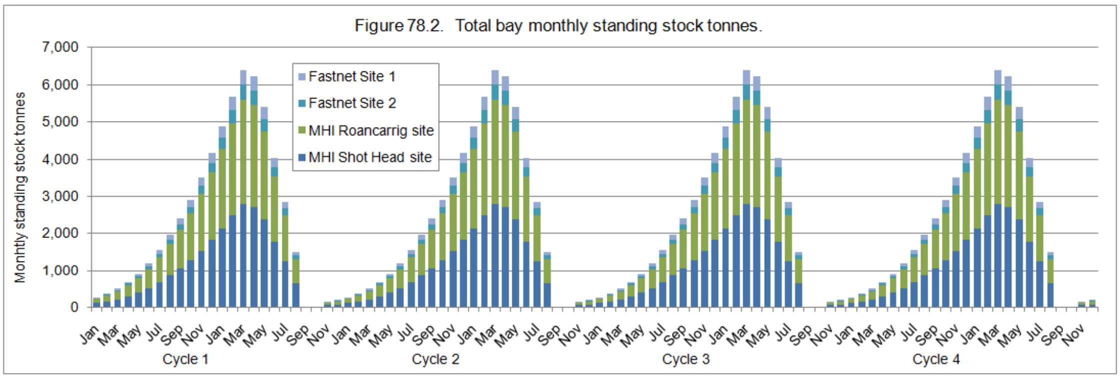
Table 21.
Shot Head EIS.
Production processes and effects.
Projected multigeneration combined soluble nutrient and solids discharge budget for all salmon farms in Bantry Bay, in synchronous production.
Model uses Biomar Ecolife Pearl organic ration for all sites; see Tables 15 and 16.

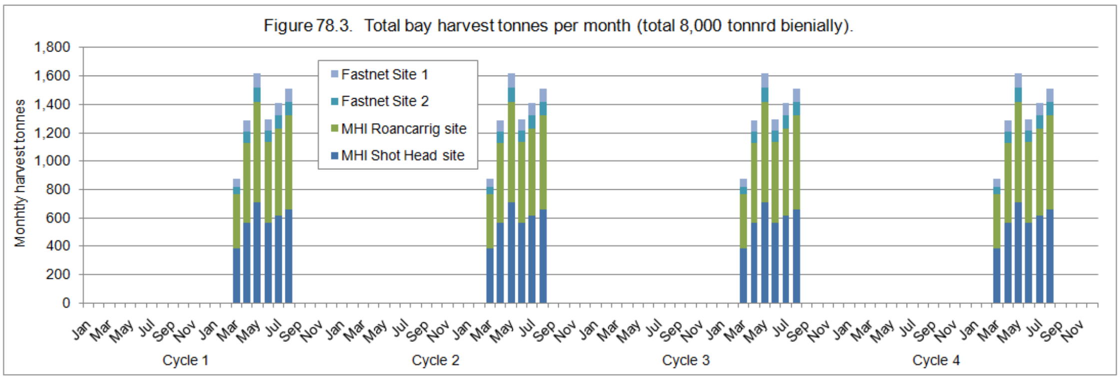
Key: [green] Peak all farms standing stock month. [pink] Peak all farms biogain / discharge month.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Combined synchronous discharge budget, all salmon famr sites in Bantry Bay (licensed and proposed)												
			Solids			Settleable carbon			Nitrogen discharge T / month			Phosphorus discharge T / month		
Year	Month ending	Total bay BOD_5 T pm	Total bay waste feed solids T	Total bay faecal solids T pm	Total bay total solids T pm	Total bay waste feed C Tpm	Total bay faecal C T pm	Total bay total C T pm	Total bay solids N T pm	Total bay soluble N T pm	Total bay total N T pm	Total bay solids P T pm	Total bay soluble P T pm	Total bay total P T pm
1	Nov	8.45	1.21	6.54	7.76	0.53	2.88	3.41	0.20	1.46	1.66	0.08	0.13	0.21
1	Dec	13.30	1.91	10.30	12.21	0.84	4.53	5.37	0.32	2.29	2.61	0.12	0.20	0.33
2	Jan	20.84	2.90	16.10	19.00	1.28	7.08	8.36	0.50	3.30	3.80	0.20	0.32	0.52
2	Feb	33.72	4.32	23.97	28.29	1.90	10.55	12.45	0.81	5.31	6.12	0.32	0.52	0.85
2	Mar	51.97	6.08	33.76	39.84	2.67	14.86	17.53	1.21	7.95	9.15	0.48	0.79	1.27
2	Apr	67.18	7.86	43.64	51.50	3.46	19.20	22.66	1.56	10.27	11.83	0.62	1.02	1.64
2	May	87.01	9.95	56.62	66.57	4.38	24.91	29.29	1.98	12.09	14.06	0.67	1.09	1.76
2	Jun	112.82	12.62	71.83	84.46	5.55	31.61	37.16	2.54	15.54	18.08	0.86	1.41	2.27
2	Jul	134.61	14.81	84.26	99.06	6.52	37.07	43.59	3.01	18.41	21.42	1.02	1.67	2.69
2	Aug	144.75	15.92	83.32	99.24	7.01	36.66	43.67	1.79	17.58	19.37	1.10	1.79	2.89
2	Sep	164.87	18.14	94.90	113.03	7.98	41.75	49.73	2.04	20.03	22.06	1.25	2.04	3.30
2	Oct	197.76	21.75	113.83	135.58	9.57	50.08	59.66	2.44	24.02	26.47	1.50	2.45	3.95
2	Nov	216.71	23.84	124.74	148.58	10.49	54.89	65.37	2.68	26.32	29.00	1.65	2.69	4.33
2	Dec	241.66	26.59	139.10	165.69	11.70	61.21	72.90	2.99	29.36	32.34	1.84	3.00	4.83
3	Jan	260.69	28.68	150.06	178.74	12.62	66.02	78.64	3.22	31.67	34.89	1.98	3.23	5.21
3	Feb	236.35	26.00	136.04	162.04	11.44	59.86	71.30	2.92	28.71	31.63	1.80	2.93	4.73
3	Mar	229.26	25.22	131.96	157.19	11.10	58.06	69.16	2.83	27.85	30.68	1.74	2.84	4.58
3	Apr	156.34	17.20	89.99	107.19	7.57	39.60	47.16	1.93	18.99	20.92	1.19	1.94	3.13
3	May	82.83	9.11	47.68	56.79	4.01	20.98	24.99	1.02	10.06	11.09	0.63	1.03	1.66
3	Jun	33.75	3.71	19.43	23.14	1.63	8.55	10.18	0.42	4.10	4.52	0.26	0.42	0.67
3	Jul	21.27	2.34	12.24	14.58	1.03	5.39	6.42	0.26	2.58	2.85	0.16	0.26	0.43
3	Aug	3.00	0.33	1.73	2.06	0.15	0.76	0.90	0.04	0.36	0.40	0.02	0.04	0.06
3	Sep	No discharges; all Bantry Bay sites fallow.												
3	Oct													
3	Nov	8.45	1.21	6.54	7.76	0.53	2.88	3.41	0.20	1.46	1.66	0.08	0.13	0.21
3	Dec	13.30	1.91	10.30	12.21	0.84	4.53	5.37	0.32	2.29	2.61	0.12	0.20	0.33
4	Jan	20.84	2.90	16.10	19.00	1.28	7.08	8.36	0.50	3.30	3.80	0.20	0.32	0.52
4	Feb	33.72	4.32	23.97	28.29	1.90	10.55	12.45	0.81	5.31	6.12	0.32	0.52	0.85
4	Mar	51.97	6.08	33.76	39.84	2.67	14.86	17.53	1.21	7.95	9.15	0.48	0.79	1.27
4	Apr	67.18	7.86	43.64	51.50	3.46	19.20	22.66	1.56	10.27	11.83	0.62	1.02	1.64
4	May	87.01	9.95	56.62	66.57	4.38	24.91	29.29	1.98	12.09	14.06	0.67	1.09	1.76
4	Jun	112.82	12.62	71.83	84.46	5.55	31.61	37.16	2.54	15.54	18.08	0.86	1.41	2.27
4	Jul	134.61	14.81	84.26	99.06	6.52	37.07	43.59	3.01	18.41	21.42	1.02	1.67	2.69
4	Aug	144.75	15.92	83.32	99.24	7.01	36.66	43.67	1.79	17.58	19.37	1.10	1.79	2.89
4	Sep	164.87	18.14	94.90	113.03	7.98	41.75	49.73	2.04	20.03	22.06	1.25	2.04	3.30
4	Oct	197.76	21.75	113.83	135.58	9.57	50.08	59.66	2.44	24.02	26.47	1.50	2.45	3.95
4	Nov	216.71	23.84	124.74	148.58	10.49	54.89	65.37	2.68	26.32	29.00	1.65	2.69	4.33
4	Dec	241.66	26.59	139.10	165.69	11.70	61.21	72.90	2.99	29.36	32.34	1.84	3.00	4.83
5	Jan	260.69	28.68	150.06	178.74	12.62	66.02	78.64	3.22	31.67	34.89	1.98	3.23	5.21
5	Feb	236.35	26.00	136.04	162.04	11.44	59.86	71.30	2.92	28.71	31.63	1.80	2.93	4.73
5	Mar	229.26	25.22	131.96	157.19	11.10	58.06	69.16	2.83	27.85	30.68	1.74	2.84	4.58
5	Apr	156.34	17.20	89.99	107.19	7.57	39.60	47.16	1.93	18.99	20.92	1.19	1.94	3.13
5	May	82.83	9.11	47.68	56.79	4.01	20.98	24.99	1.02	10.06	11.09	0.63	1.03	1.66
5	Jun	33.75	3.71	19.43	23.14	1.63	8.55	10.18	0.42	4.10	4.52	0.26	0.42	0.67
5	Jul	21.27	2.34	12.24	14.58	1.03	5.39	6.42	0.26	2.58	2.85	0.16	0.26	0.43
5	Aug	3.00	0.33	1.73	2.06	0.15	0.76	0.90	0.04	0.36	0.40	0.02	0.04	0.06
5	Sep	No discharges; all Bantry Bay sites fallow.												
5	Oct													
5	Nov	8.45	1.21	6.54	7.76	0.53	2.88	3.41	0.20	1.46	1.66	0.08	0.13	0.21
5	Dec	13.30	1.91	10.30	12.21	0.84	4.53	5.37	0.32	2.29	2.61	0.12	0.20	0.33
6	Jan	20.84	2.90	16.10	19.00	1.28	7.08	8.36	0.50	3.30	3.80	0.20	0.32	0.52
6	Feb	33.72	4.32	23.97	28.29	1.90	10.55	12.45	0.81	5.31	6.12	0.32	0.52	0.85
6	Mar	51.97	6.08	33.76	39.84	2.67	14.86	17.53	1.21	7.95	9.15	0.48	0.79	1.27
6	Apr	67.18	7.86	43.64	51.50	3.46	19.20	22.66	1.56	10.27	11.83	0.62	1.02	1.64
6	May	87.01	9.95	56.62	66.57	4.38	24.91	29.29	1.98	12.09	14.06	0.67	1.09	1.76
6	Jun	112.82	12.62	71.83	84.46	5.55	31.61	37.16	2.54	15.54	18.08	0.86	1.41	2.27
6	Jul	134.61	14.81	84.26	99.06	6.52	37.07	43.59	3.01	18.41	21.42	1.02	1.67	2.69
6	Aug	144.75	15.92	83.32	99.24	7.01	36.66	43.67	1.79	17.58	19.37	1.10	1.79	2.89
6	Sep	164.87	18.14	94.90	113.03	7.98	41.75	49.73	2.04	20.03	22.06	1.25	2.04	3.30
6	Oct	197.76	21.75	113.83	135.58	9.57	50.08	59.66	2.44	24.02	26.47	1.50	2.45	3.95
6	Nov	216.71	23.84	124.74	148.58	10.49	54.89	65.37	2.68	26.32	29.00	1.65	2.69	4.33
6	Dec	241.66	26.59	139.10	165.69	11.70	61.21	72.90	2.99	29.36	32.34	1.84	3.00	4.83

Figure 78.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Combined main farm and discharge data; all Bantry Bay salmon farm sites.
Synchronous Biennial cycles (under full Single Bay Management regime)
Note changing vertical axis.







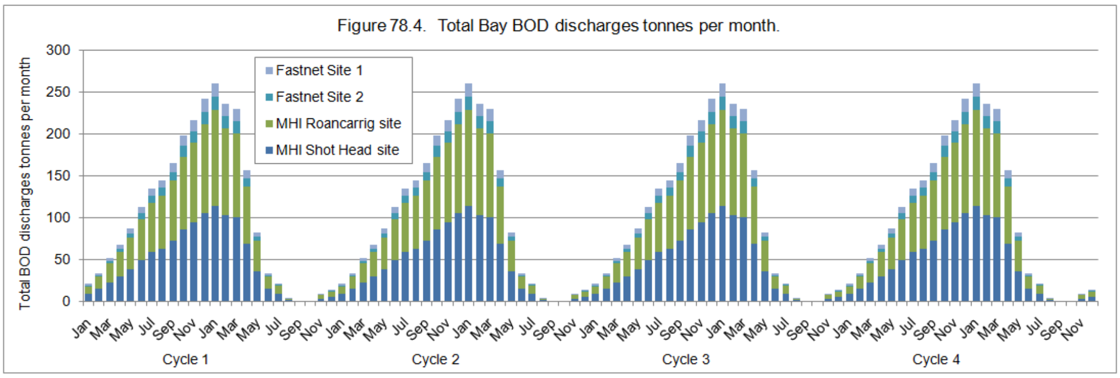


Figure 78 continued.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Combined main farm and discharge data; all Bantry Bay salmon farm sites.
Synchronous Biennial cycles (under full Single Bay Management regime)
Note changing vertical axis.

Figure 78.5. Total Bay total solids discharges tonnes per month.

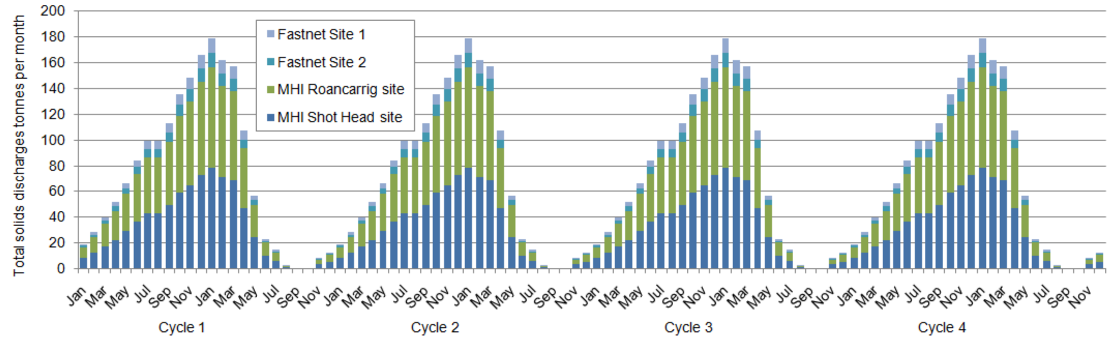


Figure 78.6. Total Bay total carbon discharges as C tonnes per month.

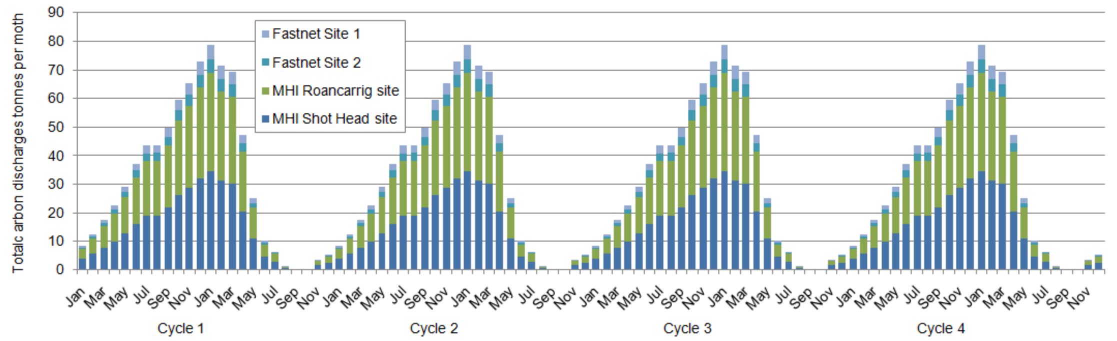


Figure 78.7. Total bay total nitrogen discharges as NO_3N tonnes per month.

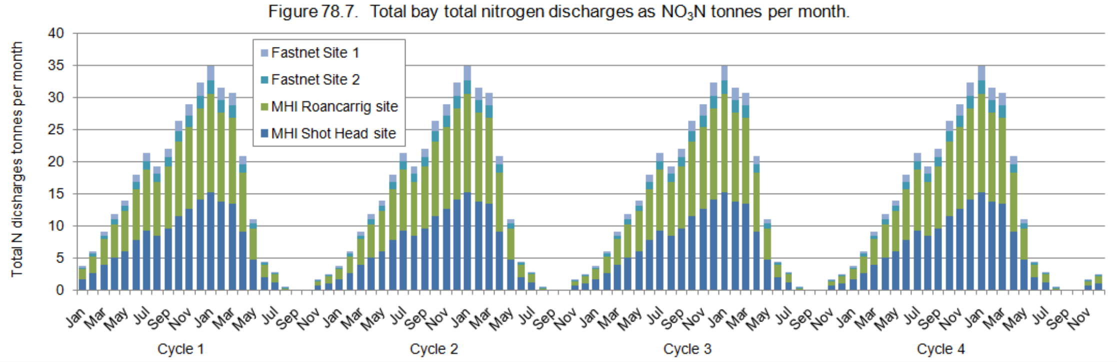


Figure 78.8. Total bay total phosphorus discharges as PO_4P tonnes per month.

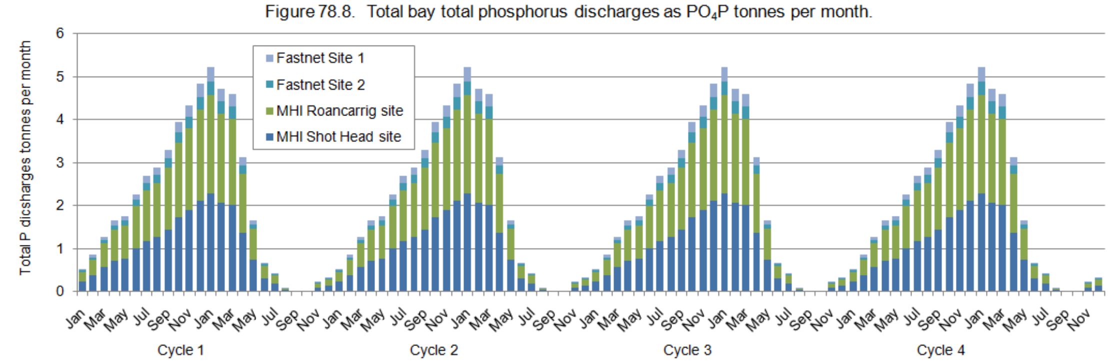


Figure 79.
Shot Head EIS.
Production processes and effects.
Bantry Bay salmon farm sites (licensed and proposed) with separation distances.

Table 22.
Shot Head EIS.
Production processes and effects.
Summarised annual discharge data for Bantry Bay sites.

Table 22.1.
MHI Shot Head (proposed) site only ; annual combined production and discharge summary data.
Note units in tonnes.

Table 22.1. Shot Head (proposed) site only; combined annual producton and discharge statistics											
Year	Peak annual standing stock tonnes	Harvest tonnes pa	Feed tonnes pa	Biogain tonnes pa	BOD_5 tonnes pa	Nitrogen discharges as NO_3N tonnes pa			Phosphorus discharges as PO_4P tonnes pa		
						Solids N tonnes pa	Soluble N tonnes pa	Total N tonnes pa	Solids P tonnes pa	Soluble P tonnes pa	Total P tonnes pa
1	218	0	1,819	1,458	466	5.97	57.51	63.48	3.57	5.83	9.40
2	2,800	3,500	2,529	2,026	645	10.30	83.21	93.50	5.04	8.22	13.26
3	218	0	1,819	1,458	466	5.97	57.51	63.48	3.57	5.83	9.40
4	2,800	3,500	2,529	2,026	645	10.30	83.21	93.50	5.04	8.22	13.26

Table 22.2.
MHI Roancarrig site and MHI Shot Head (proposed) site; annual combined production and discharge summary data.
Alternating biennial cycles .
Note units in tonnes.

Table 22.2. MHI Roancarrig and Shot Head (proposed) sites; combined annual producton and discharge statistics; alternating strategy.											
Year	Peak annual standing stock tonnes	Harvest tonnes pa	Feed tonnes pa	Biogain tonnes pa	BOD_5 tonnes pa	Nitrogen discharges as NO_3N tonnes pa			Phosphorus discharges as PO_4P tonnes pa		
						Solids N tonnes pa	Soluble N tonnes pa	Total N tonnes pa	Solids P tonnes pa	Soluble P tonnes pa	Total P tonnes pa
1	3,018	3,500	4,349	3,484	1,110	16.27	140.72	156.99	8.61	14.05	22.66
2	3,018	3,500	4,349	3,484	1,110	16.27	140.72	156.99	8.61	14.05	22.66
3	3,018	3,500	4,349	3,484	1,110	16.27	140.72	156.99	8.61	14.05	22.66
4	3,018	3,500	4,349	3,484	1,110	16.27	140.72	156.99	8.61	14.05	22.66

Table 22.3.
MHI Roancarrig and MHI Shot Head (proposed) sites; annual combined production and discharge summary data.
Synchronous biennial cycles.
Note units in tonnes.

Table 20.3. MHI Roancarrig and Shot Head (proposed) sites; combined annual producton and discharge statistics; synchronous strategy.											
Year	Peak annual standing stock tonnes	Harvest tonnes pa	Feed tonnes pa	Biogain tonnes pa	BOD_5 tonnes pa	Nitrogen discharges as NO_3N tonnes pa			Phosphorus discharges as PO_4P tonnes pa		
						Solids N tonnes pa	Soluble N tonnes pa	Total N tonnes pa	Solids P tonnes pa	Soluble P tonnes pa	Total P tonnes pa
1	436	0	3,639	2,916	931	11.94	115.02	126.96	7.14	11.65	18.80
2	5,600	7,000	5,059	4,052	1,290	20.59	166.41	187.01	10.08	16.45	26.53
3	436	0	3,639	2,916	931	11.94	115.02	126.96	7.14	11.65	18.80
4	5,600	7,000	5,059	4,052	1,290	20.59	166.41	187.01	10.08	16.45	26.53

Table 22.4.
All Bantry Bay sites; annual combined production and discharge summary data.
Synchronous biennial cycles; (full Single Bay Management regime).
Note units in tonnes.

Table 20.4. All Bantry Bay sites (existing and proposed) ; combined annual producton and discharge statistics; synchronous strategy.											
Year	Peak annual standing stock tonnes	Harvest tonnes pa	Feed tonnes pa	Biogain tonnes pa	BOD_5 tonnes pa	Nitrogen discharges as NO_3N tonnes pa			Phosphorus discharges as PO_4P tonnes pa		
						Solids N tonnes pa	Soluble N tonnes pa	Total N tonnes pa	Solids P tonnes pa	Soluble P tonnes pa	Total P tonnes pa
1	498	0	4,158	3,332	1,064	13.65	131.45	145.10	8.16	13.32	21.48
2	6,400	8,000	5,781	4,631	1,474	23.53	190.19	213.72	11.52	18.80	30.32
3	498	0	4,158	3,332	1,064	13.65	131.45	145.10	8.16	13.32	21.48
4	6,400	8,000	5,781	4,631	1,474	23.53	190.19	213.72	11.52	18.80	30.32

Table 23.
Shot Head EIS.
Production processes and effects.
Summarised annual discharge amounts per tonne growth for Bantry Bay sites.

Table 23.1.
MHI Shot Head (proposed) site only; selected annual discharge amounts per tonne growth.
Note units in tonnes and kg/tonne.

	Table 23.1. Shot Head (proposed) sites only ; selected annual discharge amounts per tonne growth.										
Year	Peak annual standing stock tonnes	Harvest tonnes pa	Feed per tonne biogain (FCR)	Per biogain tonnes	BOD_5 kg per tonne biogain	Nitrogen discharges kg / tonne biogain			Phosphorus discharges kg / tonne biogain		
						Solids N kg / tonne biogain	Soluble N kg / tonne biogain	Total N kg / tonne biogain	Solids P kg / tonne biogain	Soluble P kg / tonne biogain	Total P kg / tonne biogain
1	-	-	1.25	1.00	319	4.10	39.45	43.54	2.45	4.00	6.45
2	-	-	1.25	1.00	318	5.08	41.07	46.15	2.49	4.06	6.55
3	-	-	1.25	1.00	319	4.10	39.45	43.54	2.45	4.00	6.45
4	-	-	1.25	1.00	318	5.08	41.07	46.15	2.49	4.06	6.55

Table 23.2.
MHI Roancarrig and MHI Shot Head (proposed) sites; selected annual discharge amounts per tonne growth.
Alternating biennial cycles .
Note units in tonnes and kg/tonne.

	Table 23.1. MHI Roancarrig site and Shot Head (proposed) site; selected annual discharge amounts per tonne growth; alternating strategy.										
Year	Peak annual standing stock tonnes	Harvest tonnes pa	Feed per tonne biogain (FCR)	Per biogain tonnes	BOD_5 kg per tonne biogain	Nitrogen discharges kg / tonne biogain			Phosphorus discharges kg / tonne biogain		
						Solids N kg / tonne biogain	Soluble N kg / tonne biogain	Total N kg / tonne biogain	Solids P kg / tonne biogain	Soluble P kg / tonne biogain	Total P kg / tonne biogain
1	-	-	1.25	1.00	319	4.67	40.39	45.06	2.47	4.03	6.51
2	-	-	1.25	1.00	319	4.67	40.39	45.06	2.47	4.03	6.51
3	-	-	1.25	1.00	319	4.67	40.39	45.06	2.47	4.03	6.51
4	-	-	1.25	1.00	319	4.67	40.39	45.06	2.47	4.03	6.51

Table 23.3.
MHI Roancarrig site and MHI Shot Head (proposed) site; selected annual discharge amounts per tonne growth.
Synchronous biennial cycles.
Note units in tonnes and kg/tonne.

	Table 23.3. MHI Roancarrig site and Shot Head (proposed) site; selected annual discharge amounts per tonne growth; synchronous strategy.										
Year	Peak annual standing stock tonnes	Harvest tonnes pa	Feed per tonne biogain (FCR)	Per biogain tonnes	BOD_5 kg per tonne biogain	Nitrogen discharges kg / tonne biogain			Phosphorus discharges kg / tonne biogain		
						Solids N kg / tonne biogain	Soluble N kg / tonne biogain	Total N kg / tonne biogain	Solids P kg / tonne biogain	Soluble P kg / tonne biogain	Total P kg / tonne biogain
1	-	-	1.25	1.00	319	4.10	39.45	43.54	2.45	4.00	6.45
2	-	-	1.25	1.00	318	5.08	41.07	46.15	2.49	4.06	6.55
3	-	-	1.25	1.00	319	4.10	39.45	43.54	2.45	4.00	6.45
4	-	-	1.25	1.00	318	5.08	41.07	46.15	2.49	4.06	6.55

Table 23.4.
All Bantry Bay sites; selected annual discharge amounts per tonne growth.
Synchronous biennial cycles all sites; (full Single Bay Management regime).
Note units in tonnes and kg/tonne.

	Table 23.4. All Bantry Bay sites (licensed and roposed) ; selected annual discharge amounts per tonne growth; synchronous strategy.										
Year	Peak annual standing stock tonnes	Harvest tonnes pa	Feed per tonne biogain (FCR)	Per biogain tonnes	BOD_5 kg per tonne biogain	Nitrogen discharges kg / tonne biogain			Phosphorus discharges kg / tonne biogain		
						Solids N kg / tonne biogain	Soluble N kg / tonne biogain	Total N kg / tonne biogain	Solids P kg / tonne biogain	Soluble P kg / tonne biogain	Total P kg / tonne biogain
1	-	-	1.25	1.00	319	4.10	39.45	43.54	2.45	4.00	6.45
2	-	-	1.25	1.00	318	5.08	41.07	46.15	2.49	4.06	6.55
3	-	-	1.25	1.00	319	4.10	39.45	43.54	2.45	4.00	6.45
4	-	-	1.25	1.00	318	5.08	41.07	46.15	2.49	4.06	6.55

4.7. Quantifying the maximum impact of soluble salmon farm discharges in Bantry Bay; dilution box model.

A term now frequently used in the context of the impacts of discharges of any anthropogenic waste into a receiving water is “*carrying capacity*”. This can be defined as the "*capacity of a given environment to sustain an impact without noticeable, irreversible or long-term, deleterious change*". Carrying capacity has become a sensitive issue in respect of the excessive discharges of nutrient wastes from any source, beyond the point of sustainability into fresh waters and into poorly flushed marine and transitional (brackish) waters. Such phenomena can arise, mainly as the result of discharges of untreated or under-treated sewage and the wastes from intensive agricultural practices into receiving waters that do not have sufficient capacity to assimilate them, because they are either too small or insufficiently flushed. The undesirable result of this is termed *eutrophication*, which is characterised by unnatural levels of plant growth (algae and phytoplankton in the aquatic environment), fed by the “unnatural” levels of organic and inorganic nutrients present. The extreme result of eutrophication is the long-term loss of the natural balance of the organisms on which a normal and sustainable environment depends.

Whilst carrying capacity is easy to define, it is an complex parameter to model mathematically and is beyond the remit of this document. Nonetheless, to put the projected discharges from all salmon farm sites in Bantry Bay into context and to estimate their possible impact on their environs, the likely fate of nutrient discharges was examined. A simple *tidal prism model* [40] was used to estimate the tidal flux and nutrient and oxygen flux for a *box area* enclosing the salmon farm sites in order to establish whether Bantry Bay has the nutrient carrying capacity to comfortably accommodate these salmon farming activities.

A similar model is used in Section 2.5 to estimate the water exchange in Bantry Bay as a whole. For the current purpose, a sea area box was delineated in the bay which envelopes all currently licensed salmon farm sites, plus the proposed Shot Head site. The box area selected is shown in the bathymetric map in Figure 80. The low water sea area of the box was calculated to be 57km^2 with a mean low water depth at 34.5m by direct scaling from the map. The mean spring and neap tide depths used for the tidal prism calculation were 2.9m and 1.3m, as for the whole bay model in Section 2.5 and Table 5. The calculation of the flushing rate through the selected box is shown in Table 24 whilst Table 25 and Figure 81 show the monthly fluxes of nutrients an oxygen in the title water, derived using the calculated mean monthly flow and the physico-chemical water dataset, collected at the Bantry Bay Boatyard control site (see Section 2.6)

[40] Edwards A., Sharples F. 1986. Scottish sea lochs; a catalogue. SMBA / NCC 110pp.

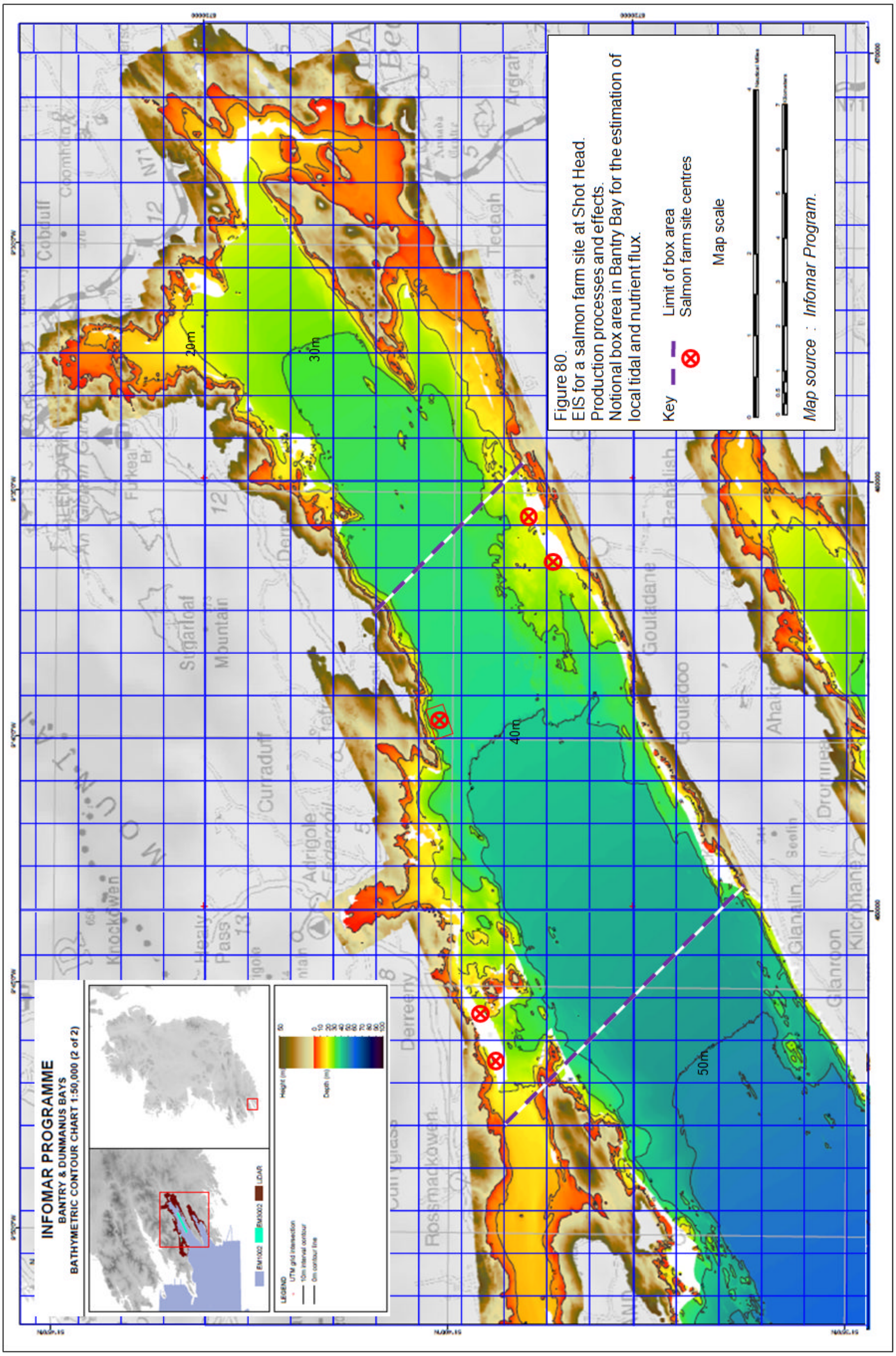


Figure 80.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Notional box area in Bantry Bay for the estimation of local tidal and nutrient flux.

Map source : Infomar Program.

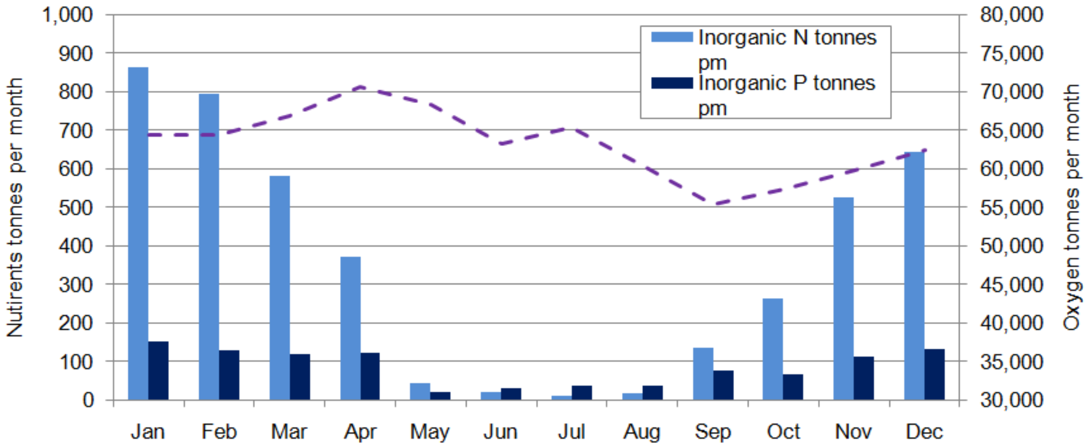
Table 24.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Tidal prism model for selected box area in Bantry Bay of 57km^2.

Parameter	Notation	Data	Units
Notional box low water sea area	A	57,000,000	m^2
Notional box mean low water depth	D	45.00	m
Thus notional box mean low water volume	V = A x D	2,565,000,000	m^3
Mean tidal range neap tide	Rn	1.30	m
Mean tidal range spring tide	Rs	2.90	m
Thus mean neap tidal volume	Pn = A x Rn	74,100,000	m^3
Thus mean spring tidal volume	Ps = A x Rs	165,300,000	m^3
Mean neap flushing time (tidal cycles)	Tn = (V + Pn) / Pn	35.62	tidal cycles
Thus mean neap flushing time (days)	Dn = Tn / 2	17.81	days
Mean spring flushing time (tidal cycles)	Ts = (V + Ps) / Ps	16.52	tidal cycles
Thus mean spring flushing time (days)	Ds = Ts / 2	8.26	days
Mean neap daily flushing rate	Fn = V / Dn	144,038,877	m^3 / day
Mean spring daily flushing rate	Fs = V / Ds	310,584,551	m^3 / day
Thus mean monthly water flux for Bantry Bay	W = ((Fn + Fs) / 2) x 30.4167	6,914,072,212	m^3/month

Table 25.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Total estimated fluxes of nutrients and oxygen, derived from prism model.

Month	Mean ambient concentration (10m control data)			Monthly flux tonnes		
	Inorganic N µg/l	Inorganic P µg/l	DO mg/l	Inorganic N tonnes pm	Inorganic P tonnes pm	Oxygen tonnes pm
Jan	125.11	22.03	9.32	865.0	152.3	64,416.1
Feb	114.87	18.91	9.32	794.2	130.7	64,414.0
Mar	84.08	17.34	9.67	581.3	119.9	66,872.9
Apr	53.95	17.57	10.22	373.0	121.5	70,666.4
May	6.49	3.10	9.88	44.8	21.4	68,292.6
Jun	3.22	4.55	9.15	22.3	31.4	63,273.0
Jul	1.59	5.43	9.46	11.0	37.5	65,437.4
Aug	2.43	5.37	8.75	16.8	37.2	60,498.1
Sep	19.83	11.26	8.01	137.1	77.9	55,390.9
Oct	38.13	9.92	8.30	263.6	68.6	57,386.8
Nov	76.14	16.12	8.66	526.4	111.5	59,849.3
Dec	93.29	19.30	9.03	645.0	133.4	62,451.4
Total flux tonnes pa				4,280.6	1,043.3	758,948.9
Mean flux tonnes per month				356.7	86.9	63,245.7

Figure 81. Bantry Bay box model; oceanic fluxes of nutrients and oxygen; T pm.



Based on the calculations set out in Tables 24, the tidal flux through the selected box area is estimated to be 6.9 x $10^9 m^3$ of seawater per month. This flushing rate tidally flushes the box area every 8.3 days (on spring tides) to 17.8 days (on neap tides) in still weather conditions. The data show that, as might be expected, the waters that flush the selected box carry very substantial quantities of nutrients and oxygen, both in and out of the bay.

Figures 82.1 and 82.2 show the fluxes, in tonnes of Inorganic N and Inorganic P, flushing the box from the ocean, relative to the combined nutrient loadings, entering the box from the salmon farm sites within it.. Figures 82.3 and 82.4 convert these data into ambient concentrations as µg/l and their elevation (ECE[41]) of ambient concentrations as a result of farm nutrient additions. Overall, Figure 82 shows the annual cyclical nature of ambient nutrient levels, as a consequence of primary production in spring / summer and decay in autumn / winter (see Section 2.7), alongside the biennial cyclical nature of farm-origin discharges running alongside total farm standing stock levels taken from Table 21, indicated by the hatched line superimposed on the graphs.

The data show that oceanic nutrient flux peaks in the winter months, reaching 865 tonnes NO_3N and 152 tonnes PO_4P each January. These figures far outweigh farm discharges, which peak at 35 tonnes NO_3N and 5 tonnes PO_4P in January in alternate years. Combined farm inputs cause the peak winter ambient N concentration (boatyard control site data) to rise from 125µgNO_3N/l to 130µNO_3N/l and ambient P concentration to rise from 22µgPO_4P/l to 22.8µgPO_4P/l, both in January in alternate years.

There are Environmental Quality Standards (EQS) set for a variety of substances which can be present in lough and bay waters where marine farms are present, which are summarised by SEPA[42]. In marine systems the EQS set for the winter value for nitrate nitrogen is 168µgNO_3N/l. The EQS for nitrate nitrogen is the most important in the marine context because it is the first limiting nutrient for marine algal (primary) production. This EQS value is superimposed on Figure 82.4, which shows ambient NO_3N and its projected elevation by the combined farm nitrate discharges. It can be seen that, even in winter months, when ambient nitrate levels are at their seasonal peak, the EQS level is not even approached. Thus combined farm nitrate discharges will make little difference to ambient nitrate levels in the bay.

41 ECE; Elevation of Concentration Equilibrium; meaning elevation of ambient parameters by fish farm wastes; a term coined in Scotland in the context of Gillibrand PA, Gubbins MJ, Greathead C and Davies IM. 2002. Scottish Executive locational guidelines for fish farming: predicted levels of nutrient enhancement and benthic impact. Scottish Fisheries Research Report **63.**

42 SEPA Fish Farm Manual www.sepa.org.

Figure 82.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Bantry Bay 57km[2] box model; estimated monthly ambient nutrient levels and predicted nutrient elevation due to combined nutrient discharges from all Bantry Bay salmon farm sites (licensed and proposed).

Figure 82.1. Bantry Bay box model ; Oceanic NO_3N flux vs. all farms' NO_3N discharge, tonnes / month.

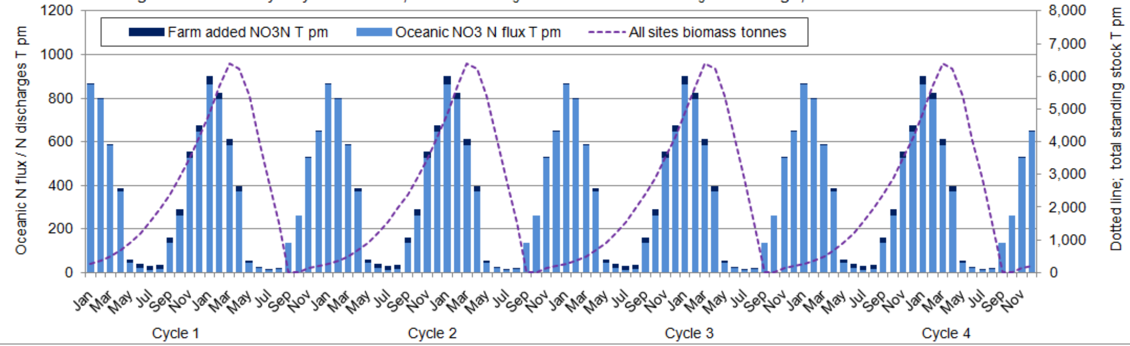


Figure 82.2. Bantry Bay box model ; Oceanic PO_4P flux vs. all farms' PO_4P discharges, tonnes / month.

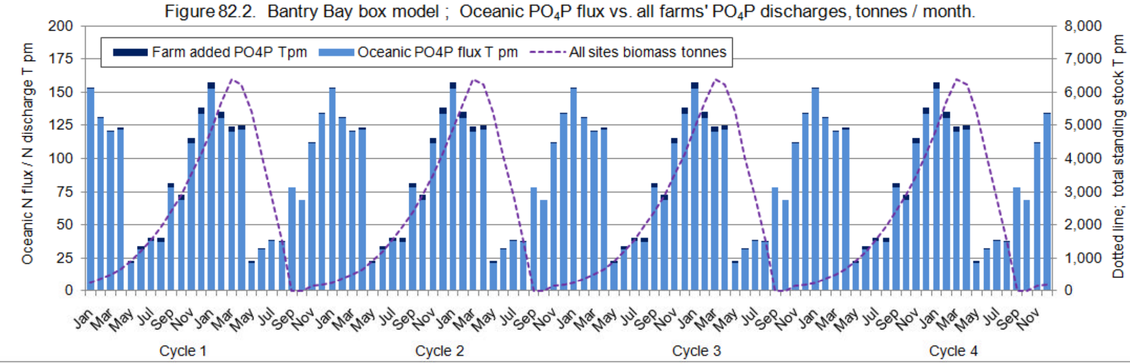


Figure 82.3. Bantry Bay box model ; Ambient NO_3N plus elevation of ambient from all farm discharges µgNO_3N.

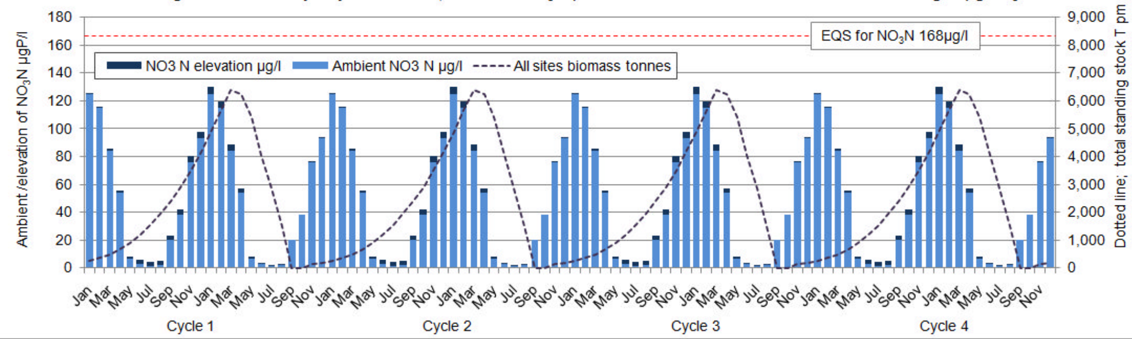
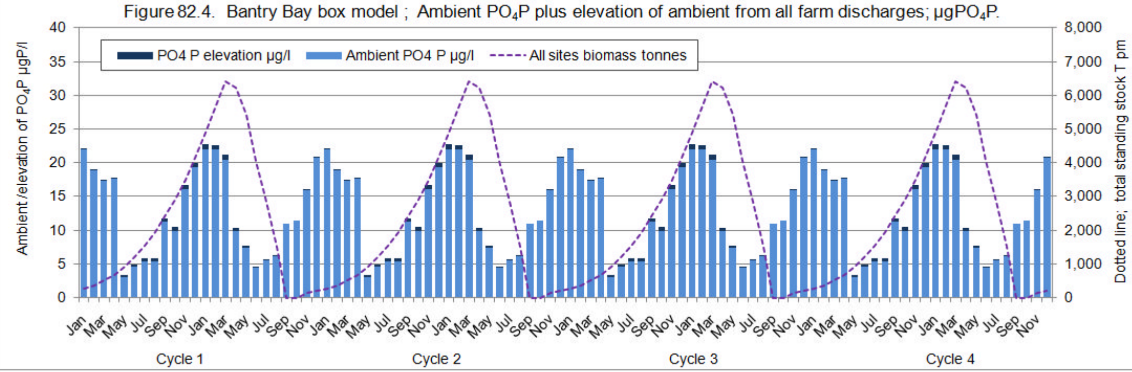


Figure 82.4. Bantry Bay box model ; Ambient PO_4P plus elevation of ambient from all farm discharges; µgPO_4P.



Monthly ambient oxygen and flux are also shown in Table 25 and Figure 81, because of oxygen's importance in the respiration of salmon farm stock and in the assimilation of the BOD of salmon farm wastes. Ambient oxygen saturation arises from the solubility of atmospheric oxygen in seawater, sustained by diffusion at the air-water interface. The natural oxygen flux in Bantry Bay will vary from month to month as a result of the inverse relationship of oxygen solubility with temperature, hence the summer dip in the oxygen curve in summer temperatures shown in Figure 81[43]. High oxygen / BOD demand can depress ambient oxygen if water exchange is poor, as can eutrophication, as explained above. Ambient oxygen availability in Bantry Bay should therefore also be considered against the oxygen demands of the combined salmon farms sites in the bay. This is shown graphically in Figure 83.

Figure 83.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Bantry Bay 57km^2 box model; estimated monthly oxygen flux, tonnes, and ambient oxygen mg/l and predicted DO change due to combined BOD discharges from Bantry Bay salmon farm sites (licensed and proposed).

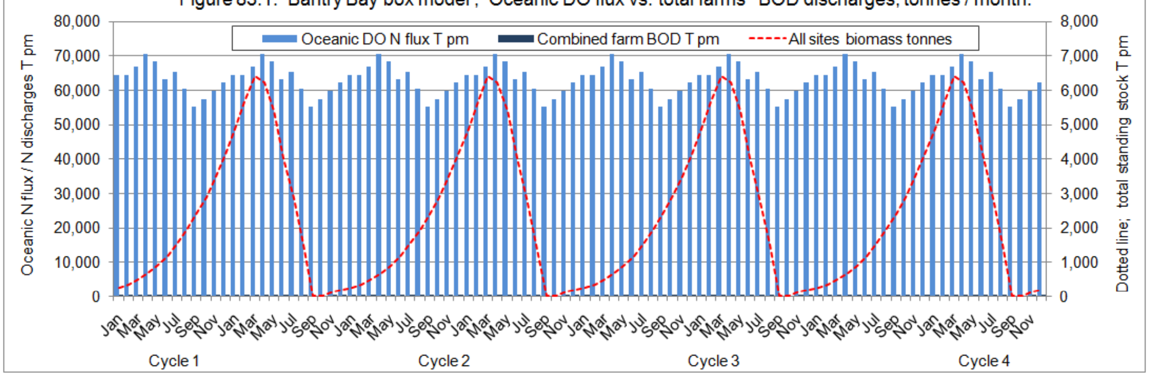


Figure 83.1. Bantry Bay box model ; Oceanic DO flux vs. total farms' BOD discharges, tonnes / month.

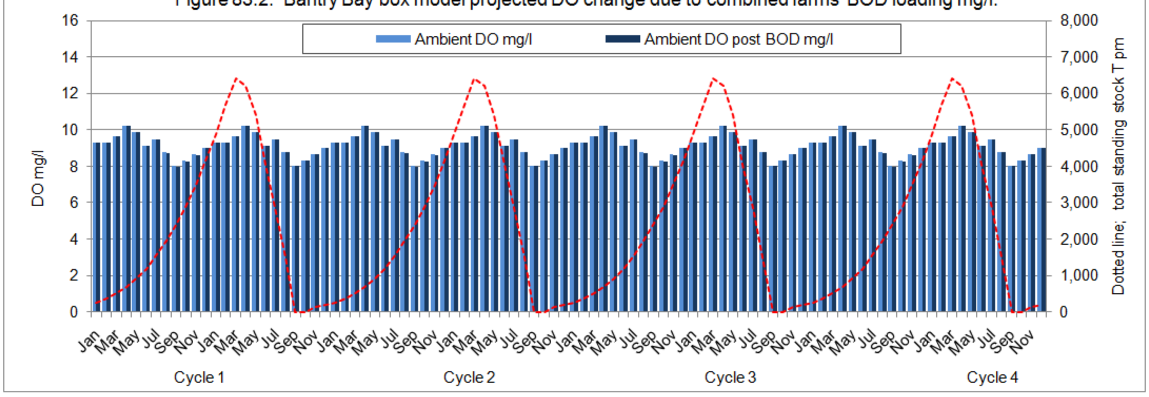


Figure 83.2. Bantry Bay box model projected DO change due to combined farms' BOD loading mg/l.

43 It should be noted that the oxygen data used in Figure 81 is the collected mean Boatyard control site data, extracted from Table 7 and Figure 49, rather than a set 100% saturated dissolved oxygen dataset, calculated from monthly ambient temperature data for the bay. The dip is not as pronounced as it would be with calculated data, presumably due to seasonal oxygen variations in Berehaven Sound, where the boatyard site is located.

Figure 83.1 shows that oceanic oxygen flux into the notional box area outweighs the BOD requirement of the Bantry Bay salmon farms by a factor of over 600 times on a per cycle (2-year) basis. Figure 83.2 indicates the projected difference in ambient DO as a result of the full assimilation of monthly BOD production by the farms. Virtually no difference can be discerned between the two columns in the graph, except close to peak farm biomass, when BOD discharges are at their greatest (see Table 21 and Figure 78.4). There can therefore be no doubt that ambient oxygen levels in Bantry Bay will not be compromised by the operation of all salmon farm sites in Bantry Bay (licensed and currently proposed), in synchronous production.

The observations made in this section confirm the ability of the carrying capacity of Bantry Bay to accommodate the discharges of the proposed Shot Head site, as well as all currently licensed sites in the bay. However they do not take account of a number of factors, which suggest that the opinions expressed are conservative and that baseline conditions in Bantry Bay may well have considerably more available carrying capacity than indicated :-

- The notional box area described used in the estimation water and nutrient fluxes in the mid-Bantry Bay area is an artefact. It has been created to aid the calculation of the mean concentrations of farm discharge streams that will occur in the area, due to the interaction between still-weather tidal forces and the discharges. The greater the box area considered, the greater the calculated dilution and dispersion will be. The box area was selected as being the smallest area that encompassed all sites. Smaller box models or other dilution modelling techniques could be used to model the discharges from individual farms and it would be found that, very close to the farms, concentrations of discharges would be greater. However, as shown by drogue studies, dye dispersion studies and well as current metering and hydrographic modelling in this area[44][45] and other areas[46] with a very similar current regime, it is indicated that soluble discharges are likely to be diluted up to 1000-fold within 120m of the site in still weather conditions and that this dilution rate would be greatly increased with wind induction.

- All water current calculations given are calculated for still-weather conditions. As pointed out in Section 2.3.2, winds blows across south west Ireland at over Beaufort Force 4 for over 50% of the time. In addition, the prevailing wind direction is westerly. Thus, for much of the year, water flux, mixing and the residual currents in the bay will be greater than estimated. This will further aid the dispersal and dilution of farm discharges from the bay area.

44 1988. Bantry Bay Water Quality Management Plan; Cork County Council.
45 2001. EIS, Beara Atlantic Salmon. Watermark.
46 1990. Current study in Kenmare Bay. Irish Hydrodata for An Bord Iascaigh Mhara in August 1990.

- All calculations made on waste generation in this section assume that waste streams are conservative. However organic wastes are non-conservative[47] by nature. Nutrients in solution or suspension are assimilated naturally through bacterial action, primary production and animal grazing in the water column. Settled solids are consumed by fish and benthic epifauna and infauna, which eventually cause their further dispersion as soluble end products from their own metabolism. Thus not only is the tidal flux of solutes and solids subject to dynamic forces which disperse and dilute them; their dilution through natural degradation and assimilation is equally dynamic. This is explained to a degree for salmon farm wastes by the feed and faecal assimilation pathways shown in Figure 73. Further, shellfish farming, which is a prominent activity in Bantry Bay, is a net remover of nutrients, organic solids and primary production from the bay. This is because these three elements are a ready source of nutrition for the growth of shellfish, which are removed from the bay waters when the shellfish are harvested. Whilst it is difficult to quantify the assimilation and removal rates of these elements from the bay waters the very fact that rapid assimilation occurs renders the estimates arising from the box model provided highly conservative.

- All projections on nutrient fluxes and their elevation by farm discharges use baseline monitored data from the Boatyard control station (see Table 7 and Figures 49 and 50). This control station superseded another site in 2004 and has been used since then for the collection of baseline data for the Roancarrig site and for other finfish farm sites in Berehaven, close to the town of Castletownbere and the Dinish Island Fisheries Industrial Estate. The position and coordinates of the Boatyard site is shown in Figure 48. Its proximity to the Castletownbere Designated Shellfish Area is also illustrated. In the Characterisation Report for the Shellfish Area[48], the key catchment pressures identified are the current absence of mains sewage treatment and ineffective septic tanks. Agriculture is identified as potential secondary pressure, due mainly to inputs of fertiliser and animal faecal run-off from the steep slopes and wet soils which characterise the area. It is felt that these factors could be impacting on ambient water parameters at the Boatyard site, in the relatively enclosed waters of Berehaven. This is illustrated, by comparison with ambient nutrient levels at the company's Lamb's Head control site, in Kenmare Bay, in Table 26. This indicates that, for winter nitrate levels at least, ambient may well be influenced by the choice of the Boatyard site and that there may be merit in choosing a new Bantry Bay control site, in more open waters clear of Berehaven Sound.

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47 Non-conservative in this context means open to change or breakdown.

48 Shellfish Pollution Reduction Program Characterisation Report Number 1; Castletownbere Shellfish Area, County Cork, Department of the Environment 2009.

Table 26.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Ambient nutrients; Boatyard and Lamb's Head control sites compared.

Month	Monhtly mean ambient concentration					
	Lambs Head control site			Boatyard control site		
	Inorganic N µg/l	Inorganic P µg/l	DO mg/l	Inorganic N µg/l	Inorganic P µg/l	DO mg/l
Jan	88.0	23.4	9.22	125.11	22.03	9.32
Feb	63.0	21.9	9.48	114.87	18.91	9.32
Mar	96.0	20.5	9.32	84.08	17.34	9.67
Apr	40.5	9.9	9.06	53.95	17.57	10.22
May	10.3	7.4	8.81	6.49	3.10	9.88
Jun	4.7	4.5	8.35	3.22	4.55	9.15
Jul	16.6	5.5	8.39	1.59	5.43	9.46
Aug	3.8	6.1	8.25	2.43	5.37	8.75
Sep	23.1	11.0	8.26	19.83	11.26	8.01
Oct	37.7	11.4	8.58	38.13	9.92	8.30
Nov	72.9	15.9	8.96	76.14	16.12	8.66
Dec	80.0	20.7	9.09	93.29	19.30	9.03

- Finally, since the Roancarrig and Fastnet salmon farm sites have been operating for a considerable number of years, it is likely that ambient nutrients in the bay already contain contributions from these sources. However, on the basis that their contributions cannot be quantified, full allowance is made for them again. Despite this very conservative approach, the EQS is still not breached by a considerable margin.

4.8. Dispersal of solids from the Shot Head site.

4.8.1. Methods

RPS Consulting Engineers[49] carried out a modelling study of the likely deposition and dispersal of solids discharged from the cages at the proposed Shot Head site. RPS were supplied with the proposed positions of the cages at the site (see Sections 1.6 and 3.3.2 of this report), numerical data regarding the feeding rate, feed conversion rate and solids production in terms of faeces and waste feed (see Section 4.3 and Table 19 of this report) and the raw data used for the hydrographic report given in Section 2.3 of this report. The model was developed and executed using the Mike 21 suite of software[50].

49 RPS Group plc, Consulting Engineers, Elmwood House, Boucher Road, Belfast, County Antrim, BT12 6RZ. 0489 066 7914. www.rpsgroup.com. Full report available from Marine Harvest Ireland, Rinmore, Letterkenny , County Donegal.

50 The Mike 21 suite of programs was developed by the Danish Hydraulics Institute. www.DHI.com.

The model was developed in several stages. The first stage was the development of a tidal / hydrodynamic model for Bantry Bay using Mike 21 HD software. Secondly the solids dispersion model was developed using Mile 321 NPA, which describes the transport and fate of solutes and suspended matter generated using data from the hydrodynamic model to provide information on the general movement of the water body. The bathymetry for the models was generated from a number of different sources; the largest proportion of which was provided by INFOMAR and included high resolution LIDAR data over much of the extent of Bantry Bay. This data was supplemented by digital chart data provided by C-Map of Norway. All data was converted to mean sea level before being used in the modelling.

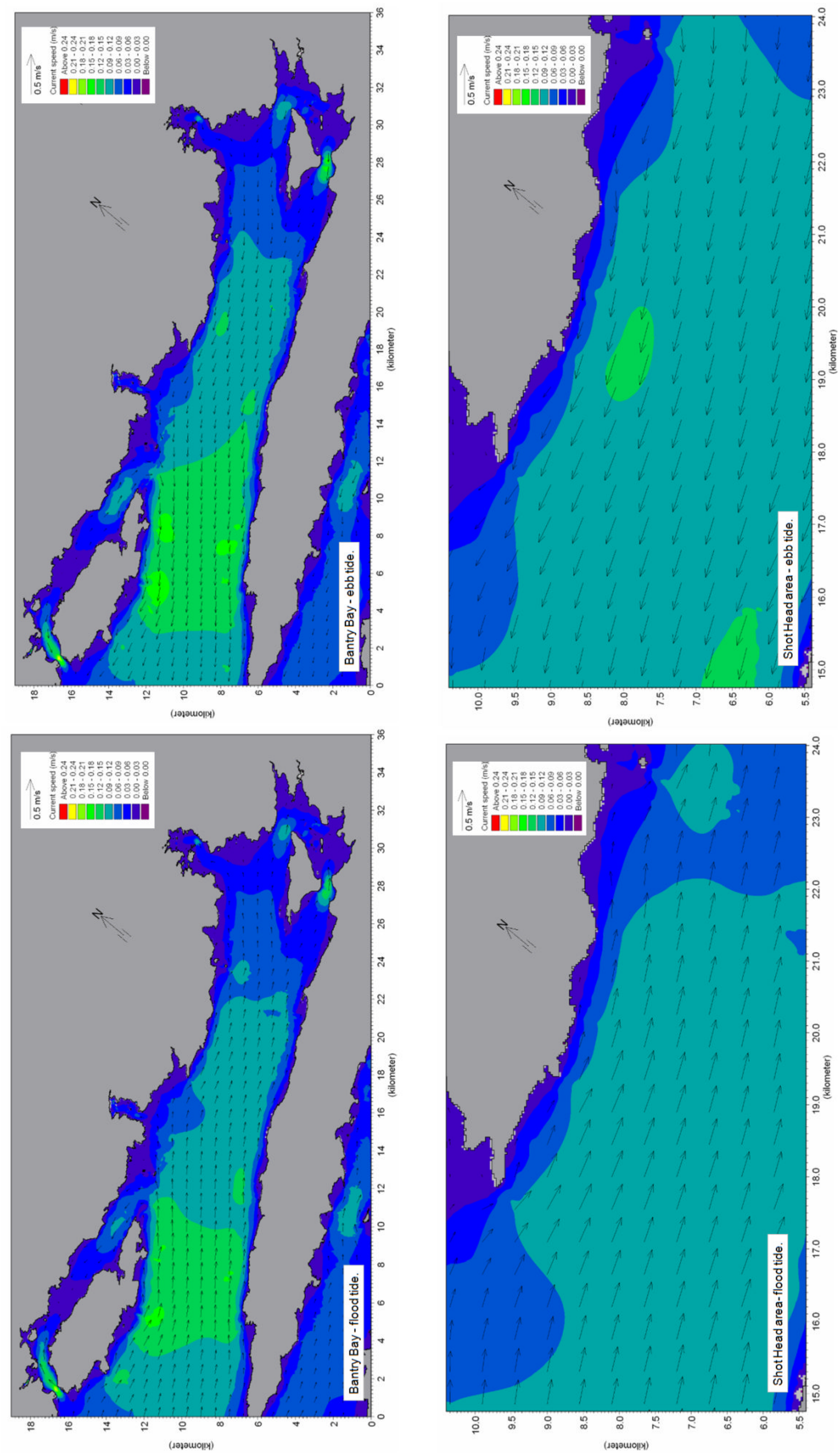
4.8.2. Results.

Typical current patterns derived from the model are presented in Figure 84 (see also Section 2.3). This shows the ebb and flood tidal patterns for the whole of Bantry Bay and for the vicinity of proposed Shot Head site area respectively. It can be seen from these figures that the current speeds within the Bay are relatively slow and at the site location (approximately 18km from the mouth of the Bay) typical current speeds are less than 15cmsec^{-1}. That said, the current pattern in the Shot Head area is much the same as that for the MHI Roancarrig site and the Fastnet Irish Seafood sites in the bay and at the majority of other salmon farm sites in the country, where currents in the range of 5 to 15cmsec^{-1} are typical. This information augments the empirical hydrographic data given Section 2.3 and goes some way to further confirm that the ebb tide is slightly greater than the flood tide in the vicinity of Shot Head, which produces the westerly residual current form the site area indicated form the empirical data.

In order to underpin the accuracy of the modelled projections, these were compared with the empirical data collected as reported in Section 2.3 and also with further empirical data collected at the MHI Roancarrig site in December 2009[51]. The numerical model and empirical data were found to be sufficiently comparable to enable the use of the model to predict dispersion in the site area, although the comparison was made difficult by the fact that the measurement of low current speeds by the ADCP equipment at the Roancarrig and Shot Head sites seems to introduce a high level of noise into the recorded results.

51 Hydrography Report of Marine Harvest Ireland on a current meter deployment at 077714E 046238N; Roancarrig, Bantry Bay County Cork. 5th to 20th December 2009. May 2010 Watermark; 26pp.

Figure 84.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Modelled flow patterns for Bantry Bay anbd Shot Head area; Ebb tide and flood tide



The dispersion model utilised the waste feed and faeces discharges calculated for the greatest stocking level / discharge month of January in Year 3, given in Table 19, of, of 12.55 tonnes of waste feed and 65.65 tonnes of faeces. Solids discharges were then simulated from separate point sources at the centres of all twelve cages. A period of one month, representing was then simulated to cover all tidal conditions.

A worst-case scenario was adopted for the modelled projections in that:-

- Solids discharges are treated as conservative in the simulation since no allowances are made for biological decomposition or assimilation by bacteria, zooplankton or the local epifauna and infauna, both of which occur naturally in such circumstances.

- All models are generated for the worst case month for discharges in the production cycle (see Table 19). This is the month with the greatest feed consumption, consequent feed wastage (at 3% of total feed) and faecal production. The month is question is month 15 of each 24-month cycle, which is when the standing stock peaks at 2,800 tonnes (see Table 16).

The hydrodynamic model that forms the basis of the dispersal study is 2-dimensional. However RPS adopted a logarithmic velocity profile to improve the simulation of conditions within the Bay, as near-bed velocities are clearly important in sediment deposition. The resuspension of sediment was controlled using the Sheild's constant, which relates to material properties and bed shear stress; the value of which was chosen from sensitivity testing carried out during previous fish farm sedimentation studies. The critical re-suspension speed used by SEPA[52] in Scottish studies, of 0.095m/sec and a critical deposition speed of 0.045m/sec (measured 1.8m from the seabed) were employed. However, in the present case, both the modelled and measured current speeds across the site were found to be low and remain below that required to maintain solids in suspension for much of the tidal cycle. This indicates that re-suspension of solids materials and their further dispersion away from the area in the immediate vicinity of the cages would be unlikely for much of the tidal cycle in normal, still weather conditions.

52 The Scottish Environmental Protection Agency who have carried out a number of studies on solids dispersion and have also cooperated in the development of a depositional model for use in the Scottish aquaculture industry.

The results of the model generated by RPS are shown in a number of figures following:-

Figure 85.1 shows the maximum projected depth of solids deposited on the seabed, in mm, during the month of peak standing stock whilst Figure 85.2 shows the depth of solids deposited, in mm, at the end of the peak standing stock month. The fact that there is very little difference between the two plots confirms that there has been little resuspension of solids from the seabed and further dispersal during the period. Further confirming the weakness of currents at the seabed

Figure 86 projects mean levels of suspended solids during the peak standing stock month. Figure 86.1 projects mean suspended solids within 50cm of the seabed whilst Figure 86.2 projects mean suspended solids thought the water column.

RPS then utilised the method developed by SEPA to project the effects of solids deposition on the Infaunal Trophic Index (see Section 2.10.2) in the vicinity of salmon farm sites[53]. This calculation is carried out the on basis of solids settlement over a period of twelve consecutive months ($g/m^2/year$) rather than a single month. The method is based on a SEPA study on benthic sampling data which investigated the effects of a range of settled solids loadings on ITI, from which the correlation graph shown in Figure 87 was derived. The ITI graph shown in Figure 88.2 was generated using the correlation data shown in Figure 87, along with the still-weather deposition modelled for Shot Head shown in Figure 88.1 (derived from Figure 86 data).

Figure 88 shows that if worst case conditions of still weather currents and zero solids assimilation are assumed, solids under and around the cages peak after 1 year at 12-13mm (in patches immediately under each cage) and 0.1 to 1.0mm (within the 25m boundary laterally and spread more than 100m beyond the cages, in the main current axis.

As shown in Figure 88.2, the result of this would be a depression of ITI to below 30 within this area. With reference to the definitions of ITI in Section 2.10.2, this would mean that the infaunal community would be degraded only in the area local to the cages and primarily immediately underneath them. The model does not distinguish the extent of the area in which the community would be "changed" (ITI 30-50) rather than degraded (ITI under 30).

53 Scottish Environmental Protection Agency 2005. Regulation and monitoring of marine cage fish farming in Scotland. Annex H. Methods for modelling in-feed anti-parasitics and benthic effects. Issue 2.3. 140pp.

Figure 85.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Solids sedimentation for peak standing stock month of production cycle.

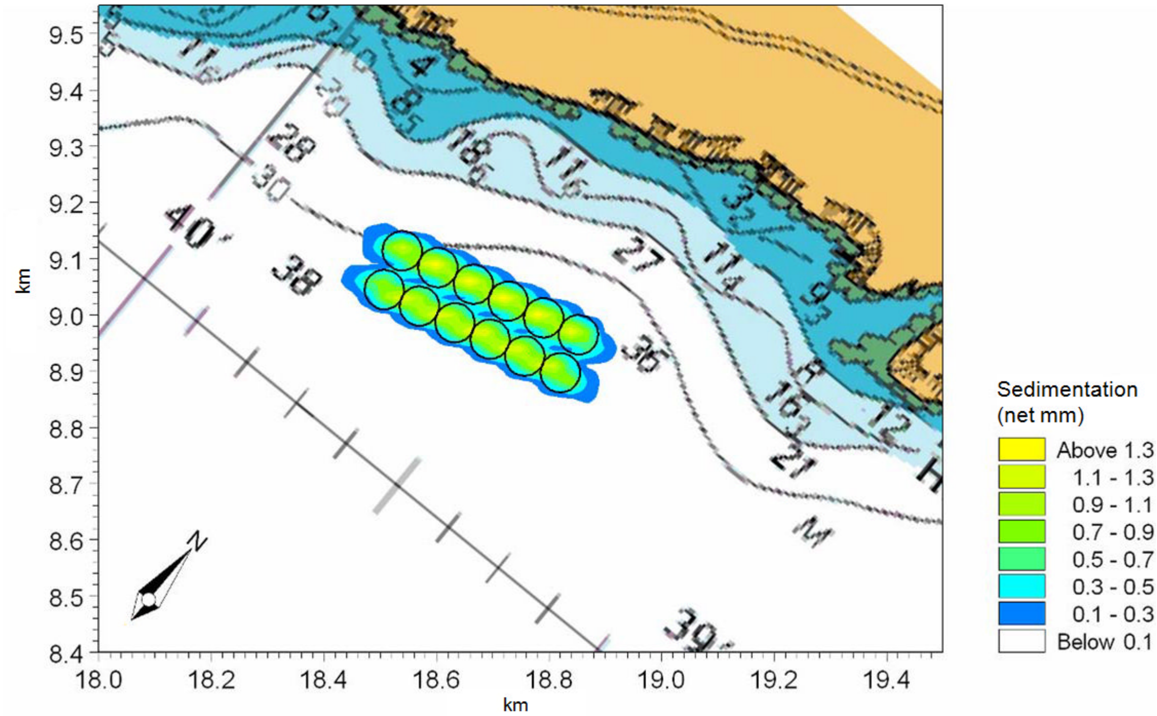


Figure 85.1. Net sedimentation (mm on seabed) following peak standing stock month.

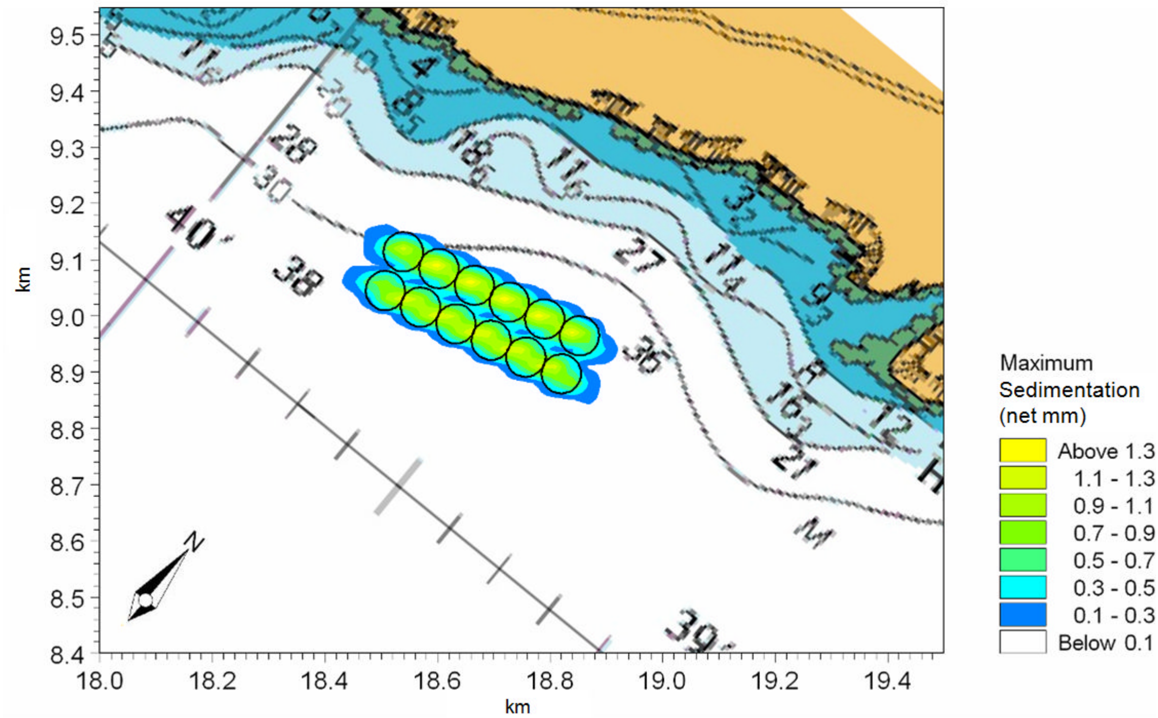


Figure 85.2. Maximum sedimentation (mm on seabed) during peak standing stock month.

Figure 86.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Solids sedimentation for peak standing stock month of production cycle.

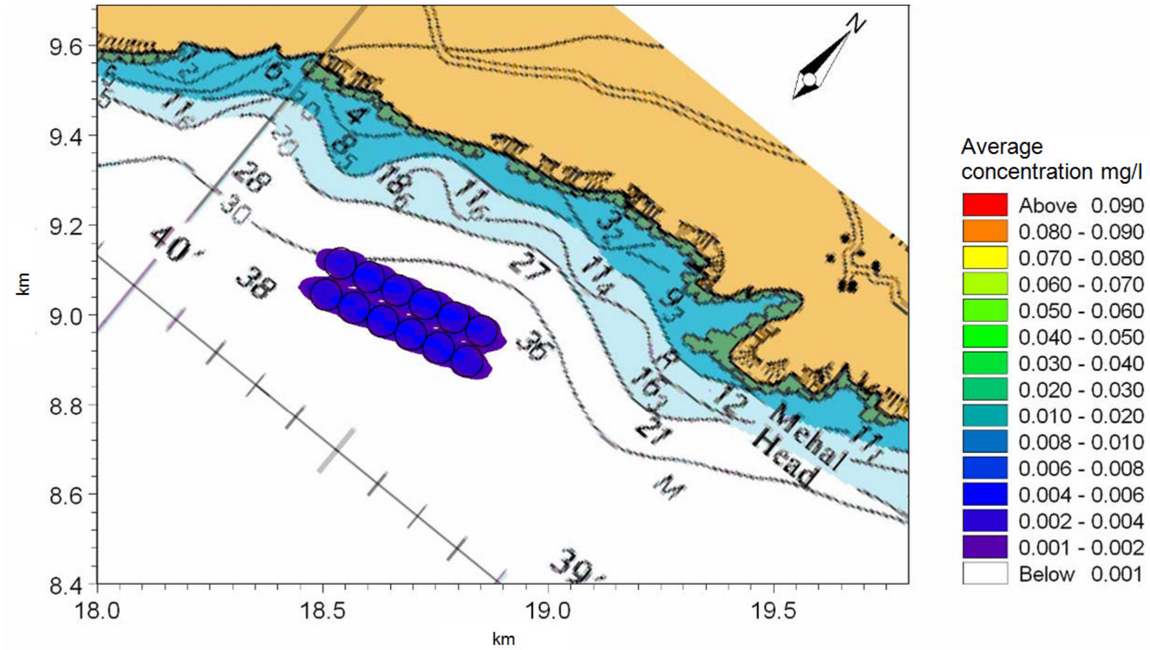


Figure 86.1. Average concentration of solids in suspension, mg/l, near the seabed, during peak standing stock month.

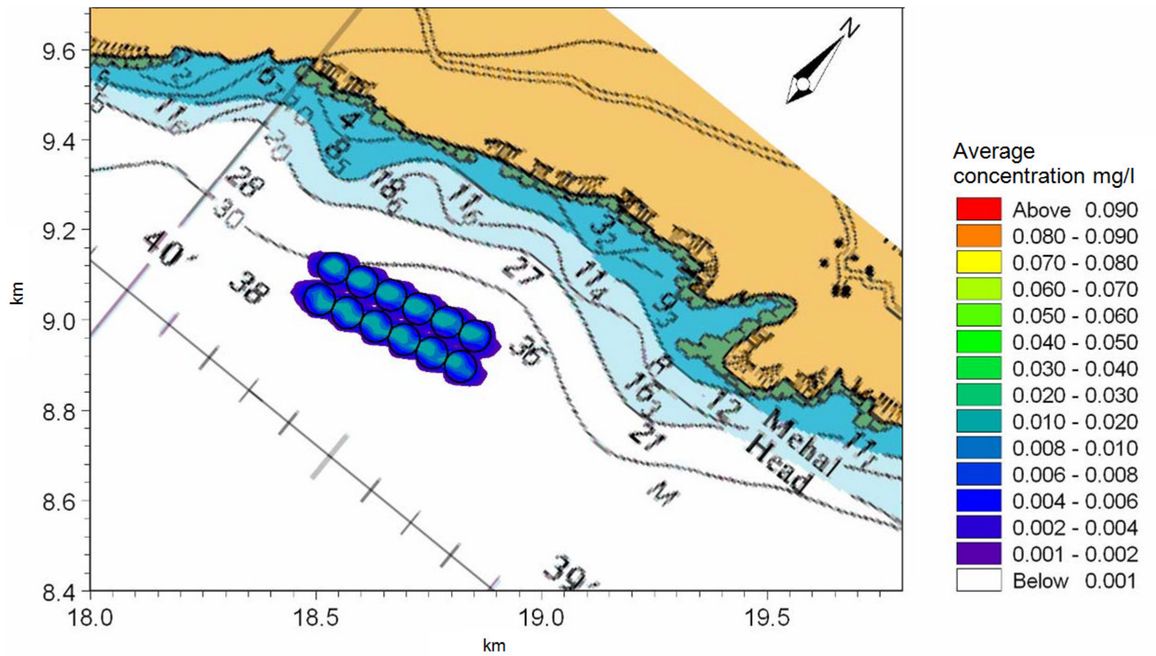
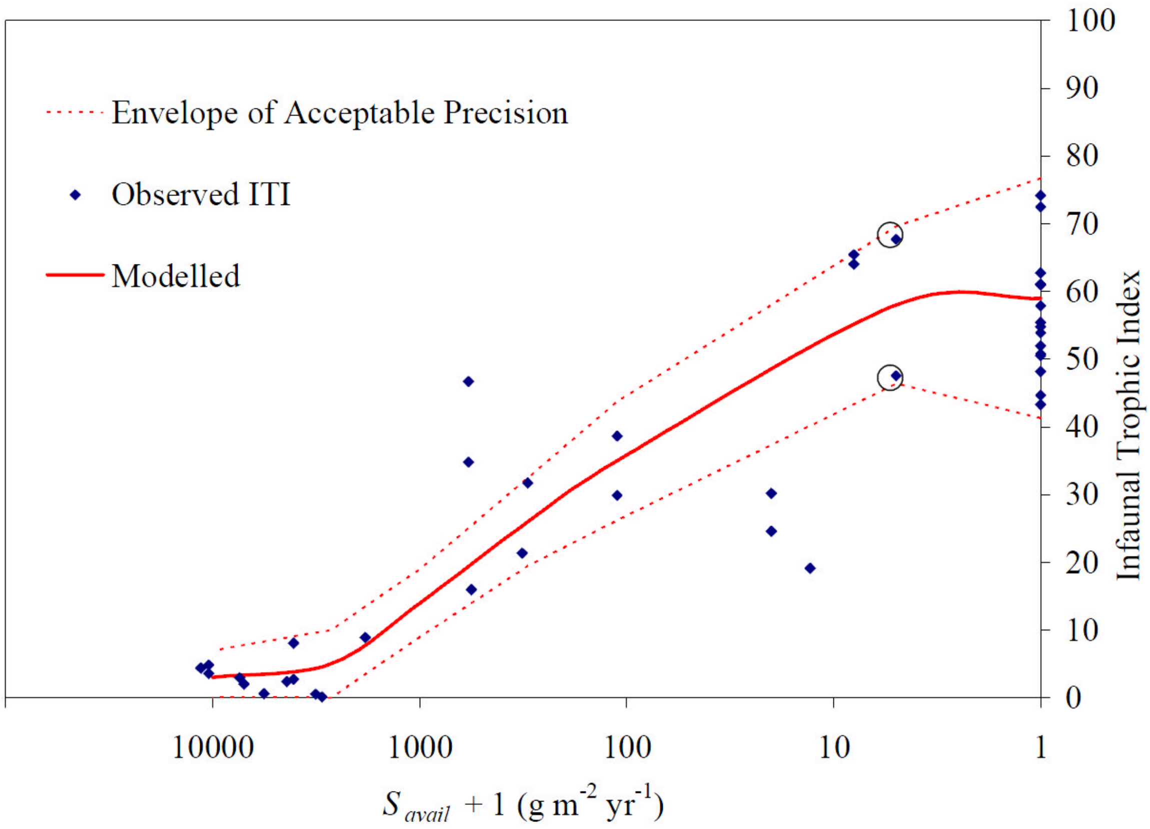


Figure 86.2. Average concentration of suspended solids (mg/l) in the water column during peak standing stock month.

Figure 87.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Modelled solids accumulation (Savail) plotted against observed Infaunal Trophic Index.
Taken from SEPA fish famr manual Annex H
Note. Horizontal axis is solids accumation in g/m2/year (+1 to enable the use of a log scale including zero readings).



4.8.2. Results.

From the point of view of judging the likely outcome of benthic impacts in <u>reality</u> (where wind and wave driven current and assimilation all combine to dictate actual sedimentation impacts), rather than by modelled projections, it is reasonable to take the modelled scenarios in the RPS report for what they are. They offer a series of worst case scenarios, indicating highly localised impacts, restricted to the areas under and immediately local to the proposed cage installation. Thus, at worst, it can be concluded that neither suspended matter nor settled matter will have any material impact much beyond the perimeter of the cage installation itself. On this basis alone, it is submitted that benthic impacts should not be a barrier to the granting of a licence for the proposed operation.

Figure 88.
EIS for a salmon farm site at Shot Head.
Production processes and effects.
Solids sedimentation for peak standing stock month of production cycle.

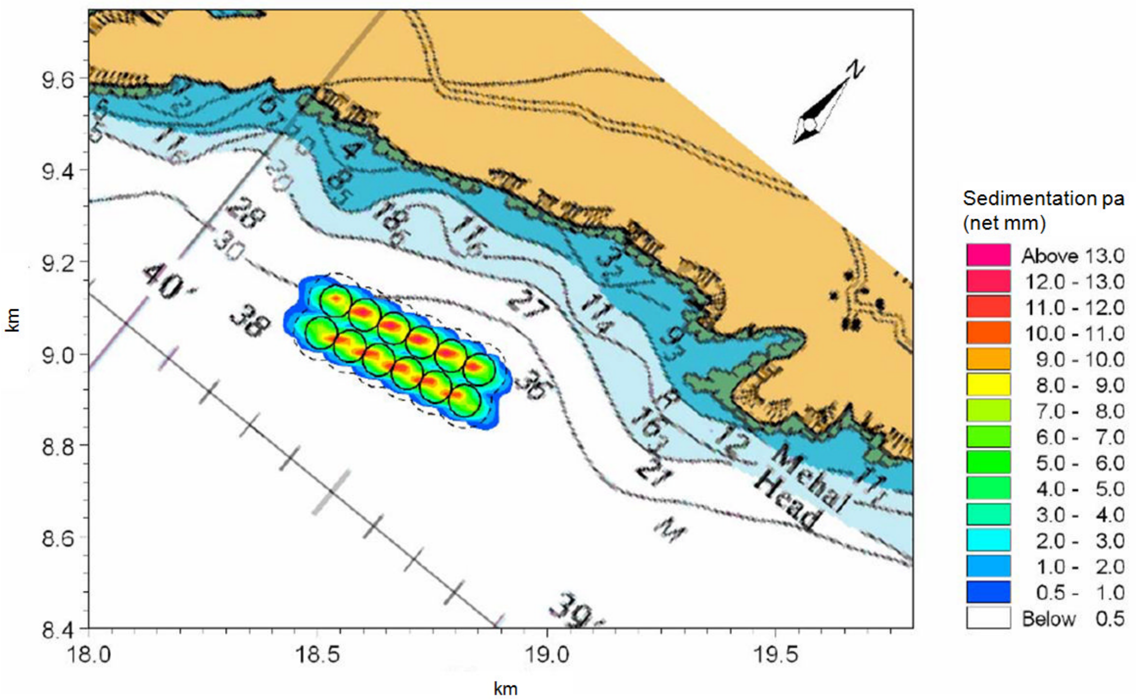


Figure 88.1. Net sedimentation (mm on seabed) following operation for one year (worst case).

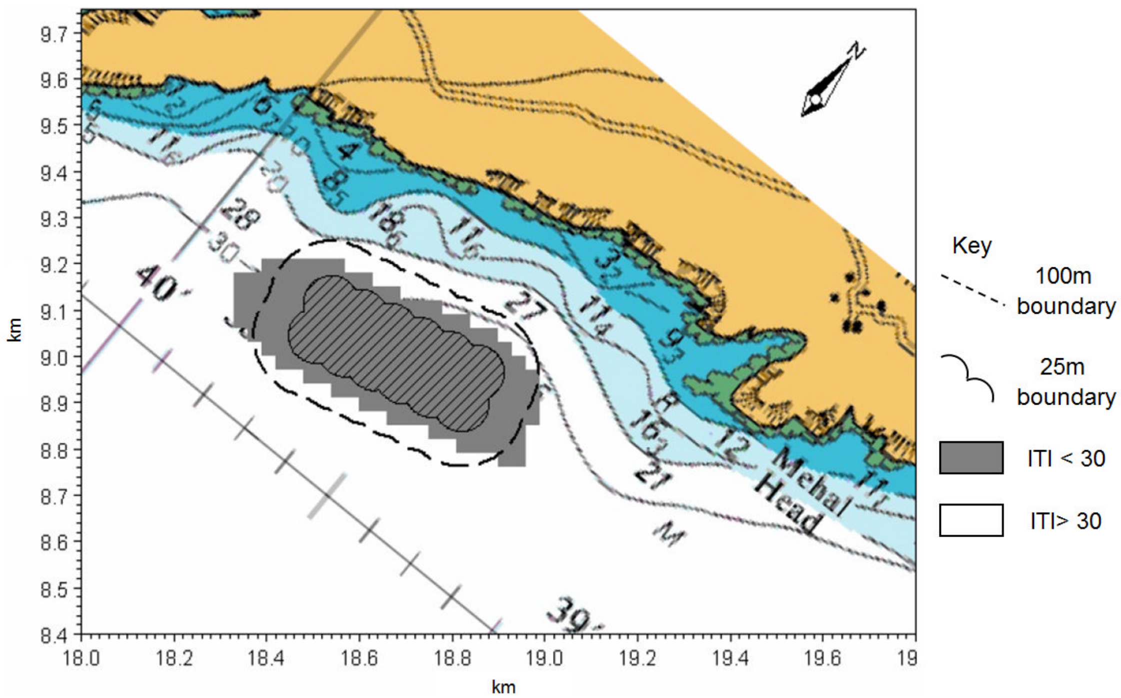


Figure 88.2. Area impacted by solids deposition (couloured grey) with ITI <30.

However experience indicates that, if the worst case scenario after one month of the highest predicted monthly deposition is well under 2mm of settled solids across the site, as predicted in Figure 85, it is unlikely that the worst predicted annual case shown in Figure 88.1, of up to 13mm deposition, will occur in practice (and it is this that the ITI predictions are based upon).

This is alluded to in remarks made by RPS in the closing pages of their report. Whilst making no estimate of likely organic solids assimilation rates, the report briefly examines the effects of wave induced transport on the dispersion of suspended material and on the resuspension of solids that have already settled. Their analysis is based on their wave climate assessment for the Shot Head site, summarised in Section 2.13 of this report.

The average wave climate derived as part of the wave climate assessment was examined to assess the proportion of time during which wave-induced flow will dominate over the tidal flow at the site. The horizontal wave equation was used to assess when the flow beneath the cages, i.e. at 15m depth, was larger than the average tidal current at the site, of around $5cmsec^{-1}$. From analysis of wind waves, an occurrence in excess of 15% and 40% was found for summer and winter months respectively. For swell waves the occurrence was in excess of 25% in the summer and almost 40% during the winter months. On the basis of these findings, the report concludes that the settlement pattern of material below the cages (and, in consequence ITI conditions) are likely differ from those derived under the purely tidal conditions, shown, for example, in Figures 26.1 and 26.2, in particular during winter (when discharges are greatest) when wave induced flow will dominate for almost half of the period.

These findings further support the case for the granting of an Aquaculture Licence and Foreshore Licence for the proposed Shot Head site.

Section 5.
Biological interactions

5.1. Sea lice and sea lice management.

5.1.1. Background

Sea lice are natural parasites of both wild and farmed fish. Two sea lice species are major parasites of European salmonids. The marine louse, *Caligus elongatus* parasitises many marine fish species including salmon. The salmon louse, *Lepeophtheirus salmonis* is more euryhaline in habit and is a parasite specific to salmonids in brackish to fully marine conditions[54]. *L. salmonis* is the more problematic of the two species for both wild and farmed salmonids. Smolts of wild sea trout (*Salmo trutta*) appear particularly susceptible to it.

Salmon farming has long been held responsible in some circles, for an allegedly “unnatural” increase in wild salmonid smolt infestation by *L. salmonis* during and immediately after their spring migration from freshwater to seawater. This view was first promulgated during the late 1980's and early 1990's and was regarded as a major factor in "collapses" of wild sea trout stocks in a number of regions where salmonids are farmed. In Ireland, a marked sea trout collapse occurred in the Western fisheries at this time, leading to a heated debate as to the role of salmon farms in the collapse. Whilst opposed views were and indeed still are held on this topic, there is no doubt that it is incumbent upon salmon farmers to operate their businesses under the precautionary principle in the control of lice on their fish. By doing so, they minimise any suspicion of impact on wild salmonids and ensure that their own stocks do not fall prey to severe lice infestation, originating from wild stock, which can be fatal, like a number of other diseases of domesticated livestock, if not held in check.

5.1.2. Monitoring of sea lice infestation.

A mandatory lice monitoring and control protocol was introduced in Ireland by the then Department of the Marine and Natural Resources (DCMNR) in March 1993. The protocol was strengthened following the Sea Trout Task Force (STTF) Report in 1994 and was last updated by the DCMNR in August 2001[55]. The protocol forms an invaluable tool in the management of sea lice on farmed salmonids.

54 From 25‰ to 35‰ salinity.

55 Monitoring Protocol No. 3 for Offshore Finfish Farms; Sea Lice Monitoring and Control, DCMNR / DAFF, 11th May 2000.

The Irish salmon farming industry was the first to monitor sea lice levels under statute, involving regular inspections by officers of the Marine Institute, on behalf of the regulator, as required by the protocol. A similar approach has been adopted in Scotland. Elsewhere, as far as is known, similar monitoring procedures to those developed in Ireland have been widely adopted, but they are carried out voluntarily, by the farms themselves. For this reason, lice control is thought to be more rigorous and lice levels on farmed fish generally lower in Ireland than in some other salmon farming nations.

A further protocol of the five issued by the regulator, *Monitoring Protocol No.5; fallowing at offshore finfish farms*[56] has a number of purposes, including the limitation of the spread of diseases and infestations, between farm sites and generations, by the use of fallowing.

These protocols agree in their main objectives of their Scottish equivalent[57]. This was a forerunner of the establishment of Area Management Agreements (AMA's) in Scotland, as recommended by both the Tripartite Working Group (2000), and the Report of the Joint Government / Industry working Group on Infectious Salmon Anaemia (2000). The counterpart of AMA's in Ireland is the Single Bay Management (SBM) scheme, which is incorporated into Coordinated Local Area Management Schemes (CLAMS), where these have been introduced. In both cases, their objective is to separate salmon farm sites into groups which lie within overlapping tidal excursions from those which lie in separate tidal excursions. Bantry Bay is the Single Bay Area containing the proposed Shot Head site, the MHI Roancarrig site and two sites operated by Fastnet Irish Seafood (see Section 4.6. and Figure 79). CLAMS has yet to be established in Bantry Bay.

The monitoring methodology set down in Protocol No. 3 comprises the inspection and sampling of fish on every salmonid farm site in each single bay area a minimum of fourteen times per annum. Inspections are to be carried out monthly, with the following exceptions:-

- During the "sensitive spring period" for migrating wild salmonid smolt especially sea trout smolt, during March to May, when there are two inspections per month.

[56] Monitoring Protocol No. 5; Protocol for Fallowing at Offshore Finfish Farms; DCMNR / DAFF, 11th May 2000.

[57] Anon. 1998. A National Treatment Strategy for the Control of Sea Lice on Scottish Salmon farms; a Code of Practice Scottish Salmon Growers Association (now Scottish Quality Salmon).

- Over the two-month period of December to January, when lice growth is slow and therefore only one inspection is required.

Each inspection comprises the taking of two samples of thirty fish, under standard conditions. The first sample is taken from a standard cage, sampled on every inspection, whilst the second is taken from another cage, selected at random. The primary objectives of the Irish sea lice monitoring protocol are:-

- To provide an objective measurement of infestation levels on farms, in particular to indicate the settlement of *chalimus*[58] stages of lice to a numerical trigger point at which treatment will be required and to show up the presence of ovigerous female lice, since it is egg hatches from the egg strings carried by ovigerous females that exert infestation pressure in the vicinity of the farm.

- To investigate the nature of sea lice infestations.

- To provide management information to drive the implementation of management and control strategies.

- To facilitate further development and refinement of management and control strategies.

The control strategy set out in the protocol has six main components:-

- Separation of generations.

- A minimum of one month's fallowing of sites between cycles.

- Early harvest of two sea-winter fish[59].

- The use of trigger levels of lice numbers on fish at which point treatment is mandatory. The "year round" trigger level is 2 ovigerous lice[60] per fish, which drops to 0.3 to 0.5 ovigerous lice per fish during the smolt migration months of March to May.

---

58 The first larval stage *of Lepeophtheirus*, following metamorphosis form the infestive copepodid stage, which is free-living, in the plankton, until it finds a salmonid host (generally a salmon or sea trout smolt) to attach to.

59 This now rarely needs to be applied since harvests of bith S1 and S0 origin fish are generally completed before the second sea winter or, at the latest, very soon after it.

60 Adult female lice bearing eggs.

- Targeted treatment regimes.

- Agreed husbandry practices.

The overall objectives of the monitoring and control strategy are:-

- Synchronised production and fallowing in single bay areas to ensure the breaking of disease and parasite life cycles. This requires the use of single year classes in each bay area. Both Marine Harvest and Fastnet Irish Seafood use single generation site occupancy in Bantry Bay and stock only with so called S0[61] fish. Thus synchronised production, fallowing and treatment of all sites in Bantry Bay is achievable with cooperation between the two companies.

- Zero ovigerous lice objective; salmon farms within single bay areas should have the objective of continuously achieving zero ovigerous salmon lice on stocks. This objective is most critical immediately prior to and during the wild smolt migration periods (February to June inclusive). This is best achieved through:-

  - Strategic timing of fallowing of sites.

  - Rigorous zone control of lice by best currently available treatment methods and synchrony of treatments between farms in the zone.

Two reports issued by the Department of Agriculture Fisheries and Food, now renamed Department of Agriculture, Marine and Food have advanced the objectives of the original protocols to some degree (DAFF 2008[62], DAFF 2010[63]). The first of these reports outlined a comprehensive range of measures to provide for enhanced sea lice control and recommended the following:-

61 Yong salmon which smoltify and are therefore ready to transfer to seawater before going through a winter in freshwater. They are generally transferred in either October or November, depending on the progress of the process of smoltification.

62 A strategy for improved pest control on Irish salmon farms. May 2008. Department of Agriculture Fisheries and Food, Dublin. 56pp.

63 National Implementation Group Report on a strategy for improved pest control on Irish salmon farms. November 2010. Department of Agriculture Fisheries and Food, Dublin. 55pp.

1. A joint DAFF / Industry Working Group to be established to identify “break out” site options in areas which have persistent sea lice problems. These options would include the possibility of using redundant sites, to optimise fallowing and separation of generations.

2. Effective and appropriate use of chemical intervention to be reviewed, to take ongoing account of changing environmental conditions, developing farming practices, sensitivity of lice to treatments and fish health issues.

3. The increased availability of well boat capacity coming on stream in the industry to be utilised for controlled bath treatments.

4. The optimisation of product rotation for strategic treatments should be given further consideration as a matter of urgency.

5. BIM and the Marine Institute to engage in intensive consultation with the fish farming industry, both with individual fish farmers and representative organisations, to ensure ongoing optimisation of management practices. To report back to the Minister in four months.

6. BIM and the Marine Institute to establish a working group to report in three months on the potential of alternative treatment approaches and to set out the steps necessary to introduce these approaches.

7. A national implementation group to be established comprising appropriate representation from:-

   - The Coastal Zone Management, Veterinary and Seafood Policy Divisions of the Department of Agriculture, Fisheries and Food.
   - An Bord Iascaigh Mhara..
   - Marine Institute.
   - Industry representatives.

   The group is to provide the Minister, within six months of its establishment, with a full update of the actual situation on the ground, the progress made to reduce sea lice levels and the further steps required, if any, to redress the situation.

8. A New role for SBM (Single Bay Management) as a focus for management cells to manage sea lice control at a local and regional level reporting to the national implementation group.

The second document reports on the implementation of the measures proposed in the first document by the National Implementation Group, established as recommended in Policy 7 above. This document also sets out the National Lice count data, collected between December 2008 and June 2010, by Marine Institute Officers, under the terms of the Monitoring Protocol No3. These data demonstrate that by and large, the implementation of proposed policies brought about a reduction in lice levels over the implementation period. Marine Harvest Ireland has implemented all the recommendations arising from these two documents, having served as an industry representative on the National Implementation Group. In particular:-

- MHI pioneered the use of well boats for lice bath treatments in Ireland, as a means of improving treatment efficacy whilst reducing medication use and the dispersal of used medication into inshore waters. MHI also arranged for well boat facilities to be available to other companies. The Standard Operating Procedure for well boat lice treatments is covered by MHI SOP 22392 [1] for Hydrogen Peroxide and for Excis® and Alphamax® in MHI SOP 29142 [2]; see Appendix 3.3, where SOP 26077 [1], for application of the in-feed treatment Slice® can also be found.

- MHI pioneered the strict rotation of treatments to reduce the risk of increase of lice resistance to specific treatments. The Standard Operating Procedure for rotation of lice treatments is covered by MHI SOP 22961 [1], appended in 3.3. A further SOP, number 26074 [1] which covers actions to be taken if lice treatment is incomplete can also be found in Appendix 3.3.

- MHI has pioneered the use of alternating sites and full single bay management; as explained in Section 1.3. The application for the proposed Shot Head licence is part of this ongoing initiative.

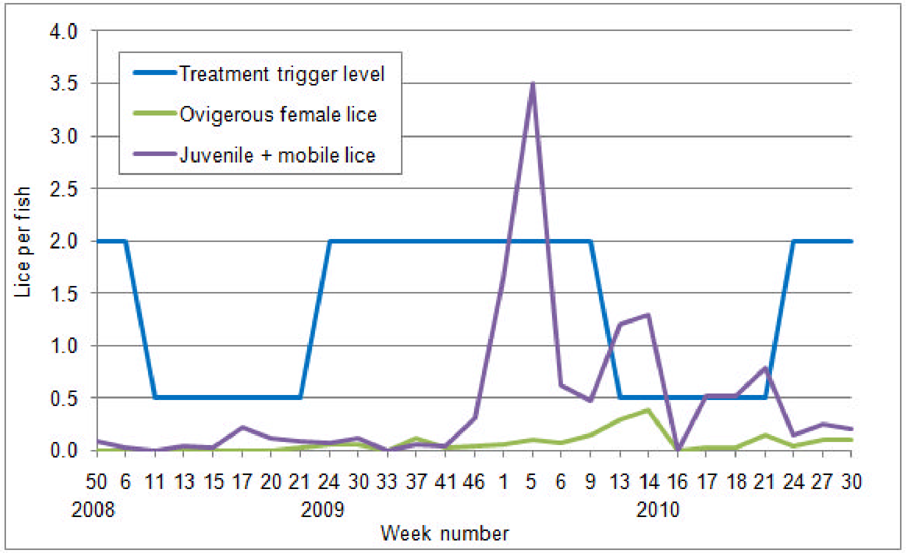
- MHI pioneered the use of vaccines against pancreas disease as a means of ensuring better efficacy of lice treatment.

These efforts have greatly assisted in combating lice infestation on MHI southwest sites, including Bantry Bay, as shown by the data given in Table 27 and Figure 89. In fact all operating sites in Bantry Bay (the MHI Roancarrig site and the two Fastnet Irish Seafood sites in the inner bay) have shown compliant lice results since the implementation of this program.

Table 27.
EIS for a salmon farm site at Shot Head.
Biological interactions.
Record of infestion by *Lepeophtheirus salmonis* (salmon louse)
on 2008 S0 salmon stock at MHI Roancarrig site; lice per fish sampled.

Year	Week number	Treatment trigger level	Ovigerous female lice	Juvenile + mobile lice	Total lice
2008	50	2	0	0.09	0.09
2009	6	2	0	0.02	0.02
	11	0.5	0	0	0
	13	0.5	0	0.04	0.04
	15	0.5	0	0.02	0.02
	17	0.5	0	0.22	0.22
	20	0.5	0	0.11	0.11
	21	0.5	0.02	0.09	0.11
	24	2	0.06	0.07	0.13
	30	2	0.06	0.12	0.18
	33	2	0	0	0
	37	2	0.12	0.06	0.18
	41	2	0.02	0.04	0.06
	46	2	0.04	0.31	0.35
2010	1	2	0.06	1.64	1.7
	5	2	0.1	3.5	3.6
	6	2	0.07	0.63	0.7
	9	2	0.14	0.47	0.61
	13	0.5	0.3	1.2	1.5
	14	0.5	0.39	1.3	1.69
	16	0.5	0	0	0
	17	0.5	0.03	0.52	0.55
	18	0.5	0.03	0.52	0.55
	21	0.5	0.15	0.79	0.94
	24	2	0.04	0.14	0.18
	27	2	0.1	0.25	0.35
	30	2	0.1	0.2	0.3
Harvest completed Site fallowed before restocking					

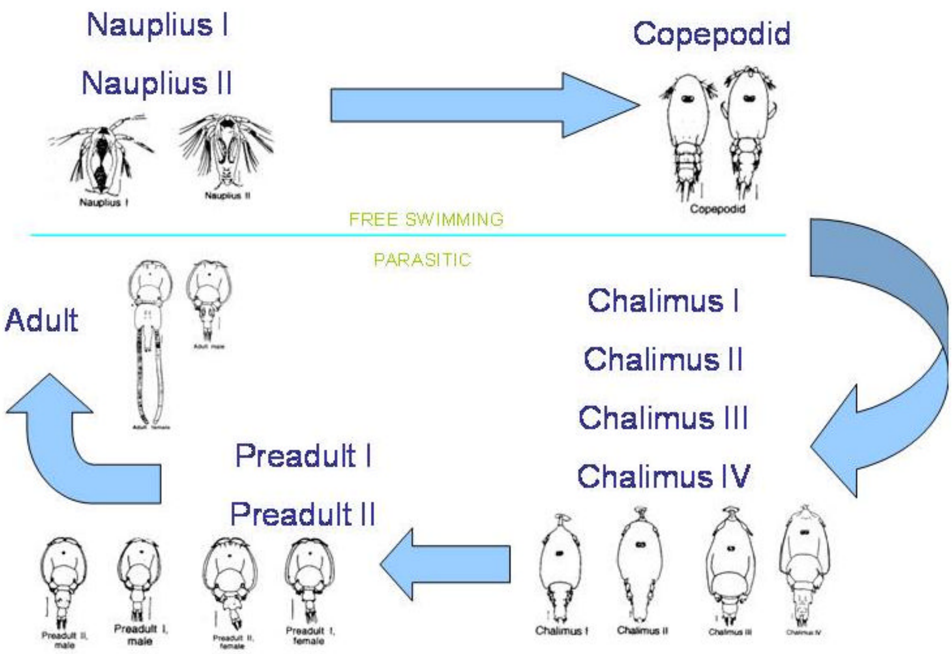
Figure 89.
EIS for a salmon farm site at Shot Head.
Biological interactions.
Graphical record of infestion by *Lepeophtheirus salmonis* (salmon louse)
of 2008 S0 salmon stock at MHI Roancarrig site; lice per fish sampled.



5.1.3. Treatment strategies and medicines to combat sea lice infestation.

Many lice species infest wild and farmed salmonids (and other marine fish species) around the world[64,65]. The principle species in Ireland, Scotland and Norway is *Lepeophtheirus salmonis*, a specific parasite of salmonid fish. Its life cycle is shown in Figure 90. The planktonic[66] Nauplius I larva hatches from the two egg strings carried by the ovigerous female louse. Hatch rate is variable according to season, host and other factors but peaks at about 400 Nauplii per clutch. The Nauplius I rapidly metamorphoses into the Nauplius II and thence to the Copepodid I and the Copepodid II, the last planktonic larval stage. The Copepodid is also the infestive stage of the life cycle of this species, which attaches to its target host through the development of a frontal filament.

Figure 90.
EIS for a salmon farm site at Shot Head.
Biological interactions.
Life cycle of the salmon louse, *Lepeophtheirus salmonis*.



64 Revie, C. et al. 2009. Salmon aquaculture Dialogue Working Group Report on Sea Lice.http://wwf.worlwildlife.org/site/PageNavigator/SalmonSOIForm

65 Boxaspen, K. 2005. A review of the biology and genetics of sea lice. ICES Journal of Marine Science 63, 1305-1316.

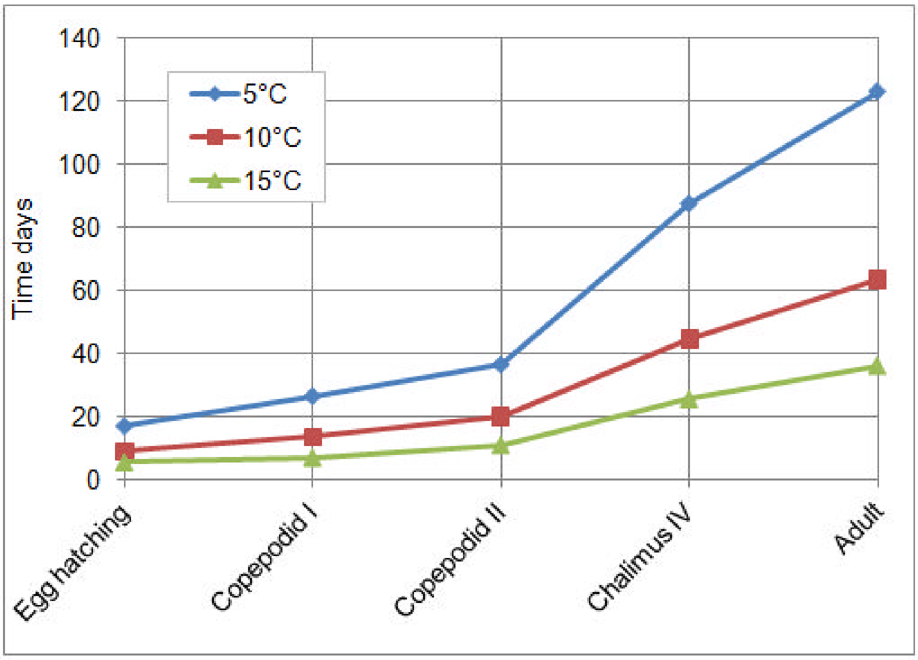
66 Carried in suspension in the water column with little or no ability to dictate its direction of travel although nauplii and copepodid larvae may have some ability to adjust their height in the water column.

Copepodids have limited strategies to assist in seeking out hosts. they can dart by up to 10cm on sensing a passing host fish. they may also be able to adjust their position in the water column, sinking towards the seabed in response to the ebbing tide (geotaxis), to assist in maintaining their position and population density, close to estuaries and inshore margins, through which their target hosts migrate.

Once attached, to the host, the louse feeds on blood and tissue. It develops through four Chalimus larval stages and two pre-adult stages before maturing. The time taken between metamorphoses for this cycle to complete, and the next generation of eggs to be produced, is temperature-dependant; as shown in Figure 91.

Lice fecundity peaks in spring, when infestive copepodid stages appear to congregate near the river mouths, from which smolts emerge. The precise mechanism behind this phenomenon is not clear but it is likely that ovigerous female lice are carried into the inshore margins near estuaries on wild adult salmon, returning to their native rivers to spawn. By this means, a critical mass of descending smolt are met by a critical mass of waiting copepodids, such that a successful infestation ensues.

Figure 91.
EIS for a salmon farm site at Shot Head.
Biological interactions.
Lepeophtheirus salmonis ; development time vs. ambient temperature.
Source Bjorn Midttun, Inverness 2005, Pharmaq Limited.



Lepeophtheirus evolved this strategy of infesting salmonid smolt during their migration, countless millennia ago, long before the advent of salmon farming. In fact *Lepeophtheirus* must be very successful at host targeting because the clutch size of lice juveniles is quite small for a parasite that releases its young into open waters to complete its life cycle rather than directly onto a host species.

Copepodids cannot feed and only survive as long as their internal yolk supplies last. Any that fail to find wild hosts drift seawards and die, within ten days or so, dependant on temperature, as their yolk supplies run out. Inadvertently, salmon farms offer a new, alternative host source since they are situated at fixed locations downstream of river mouths and their relatively high stocking density mirrors the natural shoaling of their wild cousins, prior to their migration dispersal. However, whilst wild fish disperse seawards from their native estuaries, effectively ending their exposure to the parasite, farmed salmon remain at high densities, within the confines of their cages. This makes it easy for chance encounters with small numbers of drifting wild copepodids to result in widespread infestation of farm stocks within one or two lice generations if the infestation if not treated. This is the primary means of lice infestation of well-managed salmon farms, their secondary route being infestation by copepodid drift from one farm site to others, downstream of it.

Infestation routes and treatment strategies for *Lepeophtheirus* are illustrated by the empirical data given in Figure 89 and Table 27. This indicates that ovigerous female lice on the MHI Roancarrig site only reached 0.4 per fish once throughout the entire production cycle for 2008 origin S0 fish. The fish on the Fastnet Irish Seafood site in Inner Bantry Bay showed equally low infestation levels[67]. Thus farm-origin infestation pressure (arising from egg hatches from ovigerous female numbers on farmed stock) was maintained low. Prior to week 5 of 2009, ovigerous lice levels remained between zero and 0.1 lice per fish in the cages sampled in the bay. Despite this, a spike of settled juveniles occurred in week 5. It is assumed that this can only have arisen from a flush of wild-origin copepodids in the bay which settled on farmed stock, which then required treatment. This juvenile settlement caused a low spike in ovigerous females on the farmed stock around week 12 but this was also successfully treated, such that the minimal trigger level of 0.5 ovigerous female lice per farmed fish was never

[67] National Implementation Group Report on a strategy for improved pest control on Irish salmon farms. November 2010. Department of Agriculture Fisheries and Food, Dublin. 55pp.

breached and both ovigerous female and juvenile / mobile numbers returned to low levels.

This illustrates the principal objective in lice treatment, which is to avoid the development of ovigerous female lice, since it is hatches of Nauplius I larvae from ovigerous females that causes the spread of infestation. It also illustrates that reduction in the numbers of ovigerous females can be achieved by killing lice any stage of their development, once they have settled onto the host fish.

The use of treatments that are effective against *all* stages of lice therefore has its advantages. Universal effectiveness can be achieved by the use of the oral treatment Slice®, and by the bath treatments Alphamax® and Hydrogen Peroxide, using well boat well tanks. A further bath treatment, Excis®, is effective against lice stages from Chalimus III stage to adult. However, whilst Excis® is licensed for use, MHI focus their treatment strategy on the use, in rotation, of Slice®, Hydrogen Peroxide and Alphamax® only. Dosing rates, treatment methodologies and medicine details can be found in the Standard Operating Procedure sheets (SOP's) and Material Data Safety Sheets (MDSS's) for these medicines in Appendix 3.2.

The recommended lice control strategy focuses on the targeting of treatments to clear the farmed stock of all lice stages, prior to onset of winter, carried out synchronously and by the same method for all sites in a single bay. This is because any juveniles remaining on the fish at that time enter a long, over-winter development cycle of up to ten weeks. As a result, when temperatures start to rise again in spring and *Lepeophtheirus* approaches peak fecundity, these pre-winter juveniles reach maturation. Breeding ensues, with the development of ovigerous female lice. Clutches of nauplius 1 larvae hatch, which have the potential to create an early spring increase in lice infestation pressure, both for farmed fish and migrating wild stocks during this period (subject to farm locations relative to rivers and local hydrography, see Section 5.2). in combination with its stocking / fallowing strategy, which is designed to break infection and infestation cycles by leaving sites fallow synchronously within bays for a minimum of 6 weeks per season, MHI focuses its lice treatment regime on the eradication of lice, with an emphasis on clearing fish of lice prior to the onset of winter. Fish are treated at other times of year as infection levels and harvest dates dictate, by the use of available (licensed) treatments in rotation. The details of the three treatments used by MHI follow.

1. Slice® in-feed treatment.
   See Slice® data sheet in Appendix 3.2. Slice® was developed and licensed specifically as an oral treatment against salmonid lice infestation. It has superseded a range of earlier oral and bath treatments because of its ease of use, effectiveness against all lice parasitic stages, and environmental acceptability, resulting from its rapid degradation post-treatment and required short pre-sale withdrawal time.

   Slice® is a proprietary pre-mix containing 0.2% Emamectin Benzoate (EmBZ), for surface coating onto salmon feed, at a rate of 5kg Slice® / tonne of feed. Slice® is supplied in 2.5kg sachets of pre-mix, containing 5g of EmBZ in an inert matrix. Thus one sachet of pre-mix is sufficient for wet-coating or dry-coating onto feed pellets, to produce 500kg of medicated feed. The recommended rate is 50μg EmBZ per kg fish biomass per day for seven consecutive days. Thus each tonne of biomass requires 5kg of medicated feed per day (that is at a feed rate of 0.5% body weight per day) for the seven-day treatment period. Feed medicated with Slice® is generally supplied via the feed manufacturer, using the appropriate quantity of Slice® pre-mix, supplied to them under veterinary prescription.

   Slice® acts on the lice by binding to specific high-affinity binding sites, resulting in increased membrane permeability to chloride ions and disruption of a number of physiological processes, most notably neurotransmission. Slice® protects fish against lice for ten or more weeks, subject to temperature.

   It has been determined that 10% of the EmBZ dose is excreted during the treatment period. Of the remaining 90% of the chemical, approximately 99% is excreted over the subsequent 216 days. This excretion has an exponential decay profile such that 50% of the chemical remaining in the fish is released, on average, over each ensuing 36 to 37 day period, that is, approximately 2.5 Spring / Neap tidal cycles, although this varies with water temperature. It has been determined that EmBZ breaks down into “non-toxic” sub-compounds with a half-life period of 250 days.

   Schering-Plough, the manufacturers of Slice®, state that no withdrawal period is necessary post-treatment, prior to human consumption, on the condition that salmon are not treated more than once in the 60-day period prior to the fish being harvested.

Despite this recommendation, the Norwegian Government recommends that a minimum withdrawal period of 175 degree-days be used from treatment to first harvest for human consumption. This is approximately two weeks at 12 °C to 14°C. This withdrawal period will be applied at the Shot Head site.

2. Alphamax® bath treatment
   Alphamax® is manufactured by Pharmaq Limited. Its active ingredient is the synthetic pyrethroid Deltamethrin. Pyrethroids are as group of natural and synthetic chemicals which act on insects and related organisms (such as sea lice) by blocking neural transmission pathways. Deltamethrin does not bioaccumulate in fish and, if released into the environment (for example if in-cage treatment is employed), less than 10% persists (and this part widely dispersed) after 10 days, whilst its half life in sediments under treated cages has been found to be 140 days, with 90% biodegraded by 12 months. However these are not issues for MHI who use enclosed well boat tanks for bath treatments.

   Treatment dosage and time is 0.2ml Alpha Max® (=2µg Deltamethrin) per m^3 seawater in the well tank for 40-45 minutes. See SOP 29142 [002] in Appendix 3.3 for procedural information.

3. Hydrogen peroxide bath treatment.
   This treatment is also carried out in well boat tanks, in rotation with the other available treatments (see SOP 22961 [001] in Appendix 3.3 regarding treatment rotation). Hydrogen peroxide is a powerful oxidising agent which kills pre-adult and adult lice by the formation of gas bubbles on and within the organisms. As with other lice medicines, hydrogen peroxide must be used with care, in rotation with other treatments, to avoid the build-up of resistance, which seems to arise from the natural genetic selection of lice with reduced carapace permeability or detoxifying enzymes such as catalase or tolerance due to the use of subtherapeutic doses[68]

   The details of the use of Hydrogen Peroxide can be found in SOP 23392 in Appendix 3.3. The dose used is 1500ppm for 12 to 15 minutes, starting once the full dose of the treatment has been released into the well. One advantage of the use of hydrogen peroxide is that its breakdown products are oxygen and water, into the water column, which have no environmental impact whatever.

[68] Treasurer J W et al. 2000. Resistance of sea lice *Lepeophtheirus salmonis* (Krøyer) to hydrogen peroxide on farmed Atlantic salmon, *Salmon salar* L. Aquaculture Research **31**, 855-860.

5.2. Wild salmonid stocks

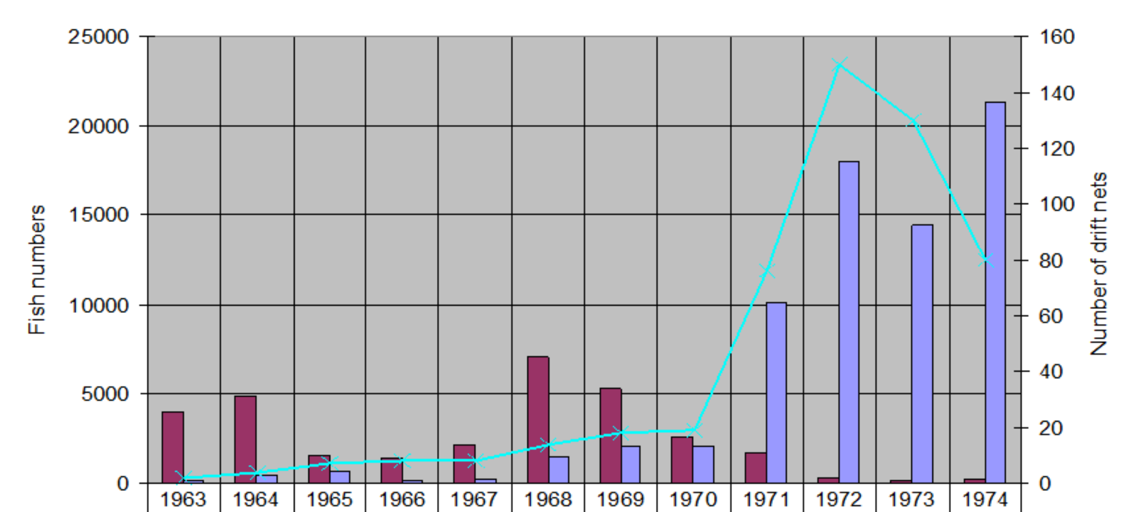
5.2.1. Background

Along with other species indigenous to Bantry Bay, such as the otter, the freshwater pearl mussel, the lesser horseshoe bat, the common seal and the Kerry slug, the Atlantic salmon is a protected species (in freshwater) under Annexe II of the Habitats Directive (92/43/EEC), which was transposed into national law in the European Communities (Natural Habitats) Regulations (SI 94/1997). However, salmon are not protected by any local conservation measure, such as a Special Area of Conservation (SAC), as it is in some other bays and rivers in Ireland.

Salmon are also protected under the EU Freshwater Fish Directive (78/659/EEC), transposed into Irish law in 1988 through the European Communities Regulation on Quality of Salmonid Waters (S.I. No. 293/1988). This requires that salmonid waters must sustain their natural populations of Atlantic salmon (*Salmo salar*), sea trout / brown trout (*Salmo trutta*), char (*Salvelinus*) and whitefish (*Coregonus*). This is achieved through a series of water quality objectives, enforced by local authorities and the Environmental Protection Agency (EPA). The Central and Regional Fisheries Boards (now combined into Inland Fisheries Ireland) originally identified 261 salmonid water systems and, overall, 22 rivers have been designated. However, no river in Bantry Bay is included on this list. That said the EPA monitor the quality of some 3,000km of river waters in Ireland triennially, including all main Bantry Bay rivers, by taking riverbed samples for infaunal analysis, by the Q-Index method. This augments the monitoring of river chemistry and nutrient levels, carried out jointly by the EPA and local authorities.

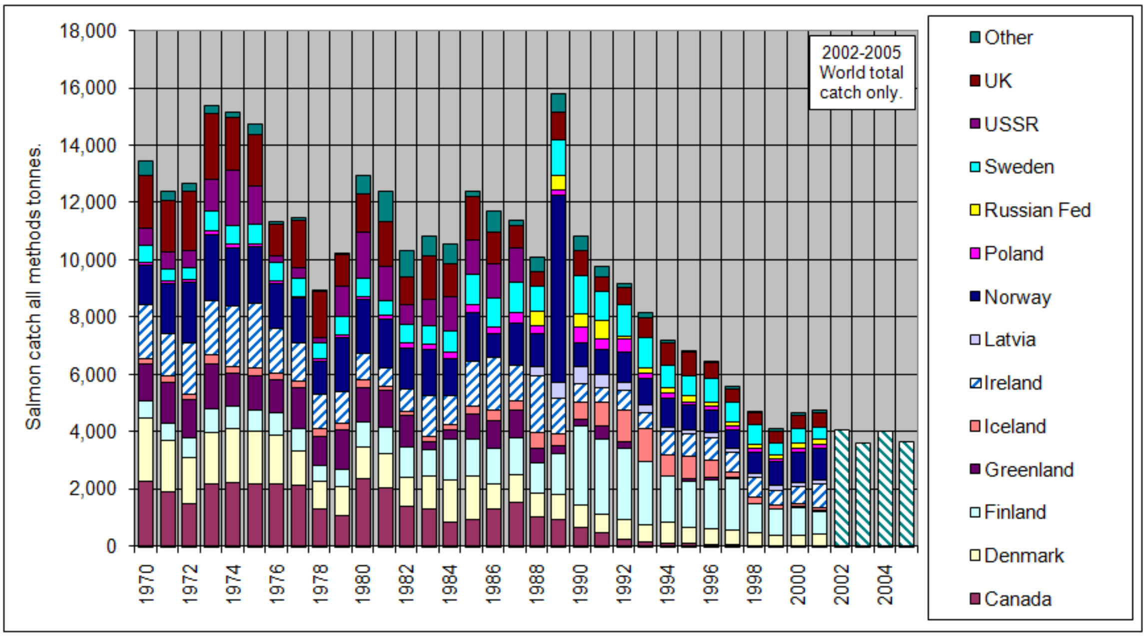
Atlantic salmon stocks have been in decline for at least a century. As long ago as 1935, the Commission on Inland Fisheries stated "*catching salmon has reached dimensions never before recorded ...and will...have serious reactions on our salmon fisheries unless it be arrested promptly*". The 1975 Report of the Inland Fisheries Commission commented that "*There has been a decline in the salmon component of runs since the late 1930's, when spring fish accounted by weight for more than half our exports… This decline was gradual at first but rapid from the mid sixties*…". Despite such warnings, Irish commercial catches actually increased in the sixties and seventies, with the more widespread use of drift nets. Bantry Bay was a case in point in this regard. Figure 92 illustrates the steep increase in drift netting and catches in Bantry Bay during this period. Figure 93 illustrates the world Atlantic salmon catch since 1970.

Figure 92.
EIS for a salmon farm site at Shot Head.
Biological interactions.
Bantry Bay; wild salmonid catches during the peak of the drift net licensing period.



	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Draft	4010	4882	1553	1398	2175	7100	5283	2572	1726	301	150	230
Drift	150	469	634	183	251	1502	2056	2100	10126	18003	14423	21378
Nets no	2	4	7	8	8	14	18	19	76	150	130	80

Figure 93.
EIS for a salmon farm site at Shot Head.
Biological interactions.
World Atlantic salmon catch, all methods, tonnes 1970-2005.



Figures 94 and 95 show Irish national salmon catches, by method and by Fisheries District[69]. Both world and national catch data show increased catches in the 1960's and 1970's (due to both increased drift netting and greater fishing effort), followed by a sharp decline, (probably a reflection of falling stocks following a period of unsustainable fishing). A brief recovery followed in the mid-eighties. Finally, further decline set in and catches reached their lowest ever by the new millennium. The data series for world catches shows that these trends were reflected throughout the geographical range of the species. Whilst thorough sea trout statistics are not available, it is clear that these trends also apply to sea trout populations.

A dominant factor in the decline was the fall in commercial catches, from the late eighties. Increasing fishing effort was not rewarded and it became uneconomic to fish in many cases. Catch was always regarded as an indicator of stock health but variation in effort had been clouding the true picture. In the early 1990's, in the face of growing international concern, generally mediated through NASCO[70], a number of nations bought out their commercial fisheries, in particular the driftnets. Ireland was one of the last countries to take this step, which it did, at the end of the 2006 season. Prior to this, the Irish catch had held fairly steady, relative to the overall international decline. For a number of years leading up to this point, the South-west Regional commercial catch (comprising Cork and Kerry Fisheries Districts, see Figure 95) was the largest of all the regional catches. Bantry Bay (in the Cork District) was a major contributor to this statistic.

In the early 1990's, numerous international, state and semi-state bodies began to seek reasons as well as solutions for wild salmonid declines. This was precipitated by a sea trout collapse in the West of Ireland. Over forty factors contributing to declines have been suggested, including legal and illegal over-fishing, pollution, disease, habitat degradation, changes in agricultural practices and land use, injudicious restocking policies and, latterly, salmon farming. Salmon farmers found themselves implicated, mainly because of apparent increases in infestation by *Lepeophtheirus salmonis*, in particular on wild sea trout smolts (see Section 5.1). These circumstances brought about the introduction of a number of monitoring and control measures for the operation of salmon farms.

69 Note that there are disparities between the two datasets used in these graphs. This is because they arise from different data sources. Nonetheless the general trends shown are valid.

70 North Atlantic Salmon Conservation Organisation.

Figure 94.
EIS for a salmon farm site at Shot Head.
Biological interactions.
All Ireland Atlantic salmon catch by catch method, '000, 1960 to 2004.

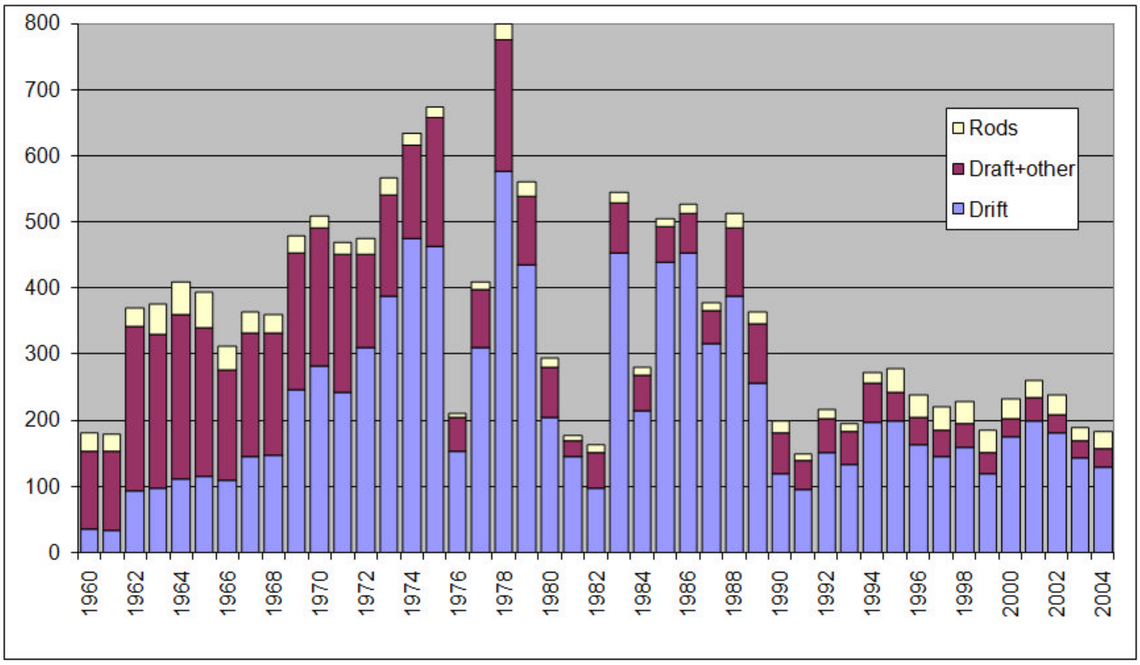
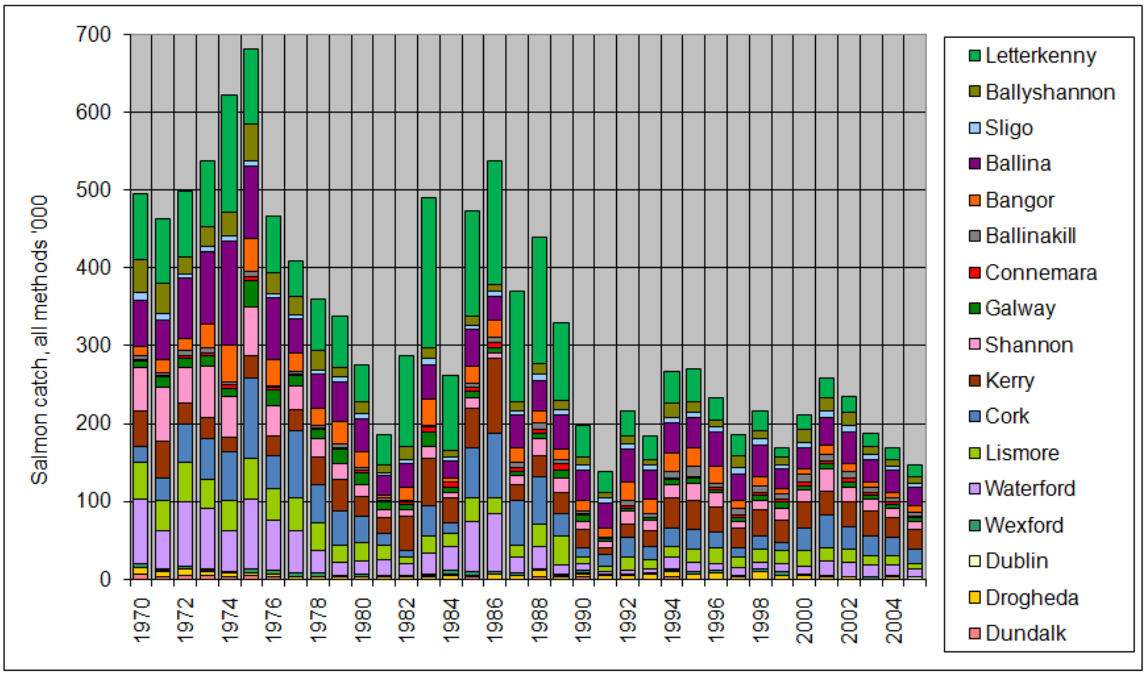


Figure 95.
EIS for a salmon farm site at Shot Head.
Biological interactions.
All Ireland Atlantic salmon catch, all methods, '000, by Fisheries District, 1970 to 2005.



These measures are incorporated into MHI's operating procedures; see Section 5.1 and elsewhere in this document. A further concern is the potential for fish farm escapes, which MHI has also addressed, with a Standard Operating Procedure in place, should such an event occur on any of their marine farm units; see Section 8.

The National Salmon Commission (NSC) became the new force in wild salmon management, early in the new millennium, assisted by advice from NASCO and ICES[71]. Through its Standing Scientific Committee (SSC), the NSC issued annual advice on the Total Allowable Catch (TAC) for the commercial fishery, as well as on angling limits. In the final driftnet season, 2006, the Irish commercial salmon fishery quota was reduced to 91,000 salmon, relative over 0.75M fish in the peak years. From 2007, the SSC's advice was provided for individual river stocks rather than for aggregated district stocks. Harvest of salmon is now only allowed in rivers where there is a surplus above the conservation limit identified and no more than this surplus will be harvested. The reported commercial catch for 2007 was 8,877 fish and the adjusted rod catch was 19,761 fish[72].

The NSC was abolished on the enactment of the Inland Fisheries Act 2010, which brought about the replacement of the Central Fisheries Board and the seven regional boards by Inland Fisheries Ireland (IFI). Inland fisheries are still regulated by the Department of Communications, Energy and Natural Resources, which issues annual regulations regarding the catch status for each river. These regulations are based on updated advice received from the SSC (which continues to sit on an ad-hoc basis) on the calculated conservation limit for each river. The conservation limit is the minimum number of fish required to conserve the naturally sustainable stock. Fishing is only allowed where a surplus exists over and above the conservation limit. Since this means of river conservation was initiated in 2007, more rivers have gradually been fully opened, or opened to catch and release fishing:-

- From 153 rivers assessed in 2007, 103 remained closed, 43 were open and 7 limited to catch and release.

- From the 141 rivers assessed in 2011, 60 rivers remain closed, 52 rivers are open and 29 are restricted to catch and release.

71 International Council for the Exploration of the Sea.

72 CFB / IFI data

5.2.2. Wild salmonids in Bantry Bay

Bantry Bay is in the south-west administrative region of Inland Fisheries Ireland. It has the longest coastline of all the fishery regions, from Kerry Head, at the southern tip of the Shannon Estuary, to Ballycotton, east of Cork city. The region comprises the Cork and Kerry Districts. The only salmonid farms operating in the region are in Bantry Bay (Cork District) and Kenmare Bay (Kerry District). There are five recognised wild salmonid rivers around the shores of Bantry Bay. These are described below, going clockwise round the bay from the north west, Beara side.

The Clashduff / Adrigole River rises in the Caha mountains. It has a catchment area of 45.71km^2. The Clashduff joins the main river about 2km north of Adrigole village. The Adrigole River enters the Bay through Adrigole Harbour. The mouth of Adrigole Harbour is about 4.4km east of MHI Roancarrig and 4.2km west of the proposed Shot head site. The Adrigole River is 6.2km east of MHI Roancarrig and 5.6km west of the proposed Shot Head site. The MHI Roancarrig site is downstream of the mouth of the Adrigole in the residual flow and current circulation around the bay whilst the Shot Head site is upstream of it. The Adrigole River is open for catch and release fishing in 2011.

The Glengarriff River has a catchment area of 85.24km^2 and drains from the Caha Mountains, including Barley Lake, and a number of smaller lakes on the eastern slopes of Glenlough Mountain. It enters the sea in Glengarriff Harbour. It is a spate rive with a reasonable grilse run from late June into July. The Shot Head site is 10.7km from the mouth of Glengarriff Harbour and 13.6km downstream of the river mouth. The river is protected as part of the Glengarriff Harbour and Wood SAC 000090. The river is open for Catch and Release salmon angling only for 2011

The Coomhola River drains the slopes of the Borlin Valley. It has a catchment area of 65km^2 . It enters the sea at Dromkeal, north of Bantry. This is a very productive spate river that gets a good run of grilse in late June which continues into late July. There is a salmon hatchery on the Coomhola River, operated by Fastnet Irish Seafoods Ltd. The proposed Shot Head site is 16km downstream of the mouth of the Coomhola River. The river is open for salmon fishing in 2011

The Owvane River enters the sea at Ballylickey. Its main tributary, the Owenbeg River, joins the Owvane near the village of Kealkil. Together, they drain a catchment of some 75m^2 of the Sheehy Mountains. The

Owvane enters the sea just south of the Coomhola River, separated from it by the headland of Eagle point, the easternmost point of Bantry Bay. The Owvane is typical of Bantry Bay rivers in that it is, by and large, a mountainous river, prone to spate with a June to July grilse run. The proposed Shot Head site is 16km downstream of Owvane River. The river is open for fishing for the 2011 season.

The Mealagh River passes over the Donemark Falls before entering Bantry Bay just north of Bantry and behind Whiddy Island. It drains a catchment area of about $46km^2$. The river is open for fishing for the 2011 season. The proposed Shot Head site is 15km downstream of the mouth of the Mealagh River.

Whilst Bantry Bay currently has three licensed salmon farms, all of the bay's salmon rivers are open for the 2011 season, two for full angling and three for catch and release only. Following the closure of the driftnet fisheries at the end of 2006, the Mealagh and Coomhola Rivers, classified in a list of 45 rivers with angling catches of over 10 fish pa, which exceeded their conservation limit were opened for the 2007 season and have been open ever since. The Glengarriff River was on a list of 34 rivers with catches of over 10 fish pa which fell below their conservation limits and was therefore closed for the 2007 season. However it is for catch and release angling for the 2011 season. The Adrigole and Owvane Rivers were two of seventy salmonid fisheries nationally with angling catches of less than 10 salmon pa which were closed by statute for the 2007 season. However, both are open for catch and release angling for the 2011 season.

5.2.3. Potential impacts of the proposed Shot Head site on wild salmonids.

Potential impacts risks can be summarised as follows:-

1. Sea lice.

2. Fish farm escapees, due to:-
   - Over-running of redds and displacement of wild eggs by mature farmed fish, with the potential to impede natural spawnings.
   - Genetic dilution by interbreeding between farmed and wild fish.

3. Transfer of disease.

4. Use of chemicals and medicines.

5. Pollution, via nutrients or sediments.

These impact risks are examined individually under headings 1 to 5:-

1. Sea lice

   The control of risks of potential infestations of wild salmonids by farm-origin lice, under the precautionary principle, was considered from a number of viewpoints in Section 5.1. It has also been pointed out that, at the outset of any new infestation cycle, the initiating step is the infestation of farmed fish by wild origin lice. Once infested, salmon farms have the capacity to generate and release large quantities of infestive lice stages if not controlled.

   It is relevant to ask what influence the distance between salmon farms and wild salmon rivers may have on the likelihood of such infestations. Copepodids, which have not found hosts, either in river estuaries or on fish farms drift in the plankton. They have no control over their position or direction of travel. In drifting between a river (wild origin copepodids) and a farm site or between a farm site (farmed origin copepodids) and a river, distance travelled cannot be measured as an uninterrupted line. It is, rather, a hydrographic distance, dictated by the speed and direction of successive ebb and flood currents. The period within which copepodids must find hosts is dictated by their yolk supplies. Copepodid longevity reduces with temperature but is generally taken to be ten days in the spring period, when smolt are migrating. Further, whether the direction of drift is towards a fish farm or towards a river, the greater the hydrographic distance or period of travel, the less dense and more dispersed the copepodid population becomes, relative to its highest density, at source, (be it a river mouth or a salmon farm). Thus the longer the copepodid travel time, the less likelihood there is of successful infestation.

   As a rule, salmon farm sites lie downstream (seawards) from salmonid river estuaries. Farm cages offer large numbers of potential hosts to drifting wild copepods that failed to find wild hosts in or near their natal estuary. Even if a small number of wild copepodids find hosts amongst farmed fish, the resulting minor infestation has the potential to become a serious problem within a few generations, amongst fish restricted within their cage nets. This can also happen most rapidly at spring to summer ambient temperature, when lice life cycle times are shortest (see Figure 91). On the other hand, if small numbers of drifting farm-origin copepodids have the unlikely good fortune to drift into a river estuary, they face a different outcome. To initiate a minor infestation amongst migrating smolts may be possible but the meeting of the critical masses hosted and parasites required for heavy infestation is unlikely to ensue and, with the migratory dispersal of the hosts, the chance to cause high levels of infestation by multiplication amongst a stationary host population (as on a farm site) is not in prospect.

The salmon louse did not evolve a copepodid stage to target salmon farm sites downstream of rivers. The species evolved so that adult lice in or near river estuaries would reach peak fecundity as smolt migrate, such that optimal numbers of copepodids could be concentrated in the waters through which the smolts seawards. This biological phenomenon undoubtedly depends on ovigerous female lice being located, by whatever means[73], close the source of hosts for their infestive offspring and to maximise the opportunity for critical masses of parasites and hosts to meet. Unlike chance encounters of wild copepodids with farmed hosts or vice versa, this is not a random event but an evolved and efficient strategy that has ensured the survival of *Lepeophtheirus* through many millennia.

These views were examined in hydrographic modelling studies in Lough Swilly, County Donegal, carried out by RPS Consulting Engineers[74],[75], commissioned by MHI, on the likely outcomes farm-origin copepodid dispersals. This work was reported in a paper to the World Aquaculture Conference in 2007[76]. The overall conclusions of the modelling studies were that, given the hydrography of Lough Swilly and the relative positions of proposed farm sites and the rivers, farm-origin lice copepodids were not capable of reaching the river estuaries in sufficient numbers to make any significant difference to infestation levels on wild fish, even when the numbers of farm-origin copepodids released in the model were far greater than had ever been known to occur in reality. Indeed, even at the greatest farm releases modelled (more than 40M copepodids released per tide, based on a population of

73 The precise means has yet to be elucidated.

74 Shannon N. 2006. Modelling water quality at Dooanmore and Anny Point sites, Lough Swilly. RPS Consulting Engineers, Belfast. 133 pages.

75 Shannon N. 2007. Water quality modelling, Lough Swilly. Addendum report; lice dispersion. RPS Consulting Engineers, Belfast. 38 pages.

76 Bass N., Shannon N. 2007. Modelling the dispersal of salmon lice (*Lepeophtheirus salmonis*) from proposed salmon farm sites in Lough Swilly, County Donegal, Ireland. World Aquaculture Conference, 2007, Sea Lice Session, San Antonio, Texas, March, 2007.

10 ovigerous female lice on every fish on the farm site), the density of copepodids capable of reaching estuaries was never much greater than 0.1 per m^3 of water. Clearly such concentrations could not comprise any part of a critical mass, capable of causing high infestation. In effect, this disproved a belief that lice infestations in Lough Swilly rivers, which reached of 50 lice per fish or more in some years, must have been caused by farmed-origin lice. The only likelihood is therefore that such infestations were caused by high natural copepodid levels arising from the presence of high numbers of ovigerous female lice in estuaries in some years, possibly assisted by favourable ambient conditions.

The study also found that, when the numbers of copepodids released from the farm sites corresponded to trigger level ovigerous female numbers, applied under the statutory protocol (the highest trigger level tested was 1 ovigerous louse per fish for all fish on the site; see Section 5.1.2), no copepodids could be detected in any river estuary.

Whilst there has been no such study in Bantry Bay, it is noted that, as in for Lough Swilly, the MHI Roancarrig site is downstream from all salmon rivers in the bay and the proposed Shot Head site is considerably downstream of all but the Adrigole River. This suggests that, if trigger levels are adhered to, as achieved at Roancarrig since acquired by MHI, the impact risk of infestation of Bantry Bay rivers by MHI farm-origin copepodids is low.

2. Fish farm escapees

No farmed escapees have been reported in Bantry Bay since MHI acquired the Roancarrig site. Impact risk depends on the maturity of the escapees and farmed fish are harvested before they fully mature. By and large, escapees are more likely to die or be preyed upon at sea than to enter a river system, in particular if they are immature, which is the most likely prospect. Fish will only enter a river system (and their choice of river is wide because their natal rivers would be far from Bantry Bay) if they escape close to maturation and survive to mature. Further, overrunning of redds or interbreeding with wild fish also only becomes a risk if escapees are mature. Overrunning and displacement of wild salmon eggs is an impact risk because farmed fish tend to mature later than wild stock[77]. However later maturation would limit interbreeding risks.

[77] Anon. 2009. Fish farming policy statement, Marine Conservation Society. www.mcsuk.org

Fears of interactions between farmed and wild salmon stocks were expressed by McGinnity et al (2003)[78]. However the scenario that the authors depict could only result from significant, persistent or annual escapes surviving to enter single rivers. Prior to the banning of the drift net fishery in 2006, annual net returns for Castletownbere indicated very low levels of farmed fish, in the range of zero to single figures. It is submitted that escapes of such numbers and regularity as to cause noticeable impact is not in prospect and completely counter to the profit objectives of commercial salmon farming. In the event that a salmon escape may occur, MHI has a Standard Operating Procedure, to mitigate its effects as far as possible; see Appendix 4.2. However, on the basis that prevention is the best route in this case, specifications of cages, nets, moorings and maintenance and working practices are all carefully considered to avoid or prevent escapes.

3. Transfer of disease.
   Disease occurrence in organic farming in covered in Section 3.4.10. Diseases contracted by farmed salmon mainly arise in the first instance from local wild stocks. Regulation of farmed stock movements is such that the introduction of diseased farmed fish from other regions is unlikely. Also, the use of vaccines and effective veterinary supervision have brought the eradication and control of diseases on salmon farms to a level that surpasses accepted levels for other livestock. In MHI's view any lower level of vigilance defeats the objectives of their business model.

4. Use of chemicals and medicines
   The use of chemicals, including antibiotics, has been reduced with the introduction of vaccines and the application of organic standards. In-feed antibiotic treatments are <u>never</u> used phrophylactically for farmed salmon as they are, routinely, for some terrestrial livestock. Modern treatments, in particular for lice, break down and disperse rapidly post-treatment, with no prospect of deleterious impact on wild salmonid stocks.

5. Pollution, via nutrients or sediments.
   Sections 2.3, 4.3 and 4.8 amongst others make the case that the rapid assimilation an dispersal of solutes and solids from the proposed site will render them free of impact risk to the indigenous fauna, including wild salmonids.

[78] McGinnity et al. 2003. Fitness reduction and potential extinction of wild populations of Atlantic salmon, *Salmo salar*, as a result of interactions with escaped farmed salmon. Proc. R. Soc. B. 2003, **270**, 2443-2450.

5.3. Impacts on flora and fauna

5.3.1. Potential impact risks

Potential impact risks on flora and fauna receptors could arise from :-

1. Smothering / displacement.
2. Turbidity change / suspended solids change.
3. Change in nutrient levels.
4. Presence of added medications or chemicals.
5. Introduction of microbial pathogens / parasites.
6. Noise / visual presence / disturbance.

Of the impact risks listed above, the groups 1 to 5 are risks towards target receptors in the water column or on the seabed. Only the last group holds any risk for target receptors above the water surface, depending on their location.

Whilst the water column and seabed impact risks identified can arise from salmon farming installations to a greater or lesser degree, the geographical range of individual effects (zone of effect) is generally limited to an area immediately under or, at worst, not much larger than the cage installation itself. Beyond the zone of effect, assimilation or dispersal and dilution of suspended and soluble impactors and bioturbation and assimilation, or resuspension, dispersal and dilution of settleable impactors reduces both concentration and impact, both in the water column and on the seabed to zero-risk levels.

5.3.2. Marine invertebrates.

The implications of this on the marine invertebrate fauna, both on and in the seabed and on the marine flora, both in the near field and far field, are dealt with in other sections of this report. However impact risks to invertebrates should be considered in light of the fact that no designation applies to any invertebrate marine species in Bantry Bay and no marine invertebrates listed in the Annexes to the Habitats Directive were found in the extensive benthic infaunal surveys (see Section 2.10) and ROV surveys conducted in the proposed seabed site area (see Section 2.11) as part of the environmental impact assessment of the site.

Invertebrate marine organisms may be open to the impact risks listed in bullets 1 to 4 above. These are considered in Section 4.8 (smothering, turbidity change and suspended solids), Sections 4.4 to 4.7 (nutrient levels), and Sections 3.4.10, 4.8 and 5.1.3 (medicines and chemicals, in particular in respect of lice treatments). In summary:-

- Due primarily to the requirements of organic standards in respect of salmon stocking density and the high digestibility of modern salmon rations, as well as to the hydrography in the site area, the anticipated extent of organic deposition on the seabed is limited more or less to the area beneath the cages. As a result, the Infaunal Trophic Index projected in Section 4.8 suggest that infaunal communities will only be degraded within a similar seabed area. The relatively shallow depth of deposition, even at worst case, suggests that this area will show rapid recovery during fallow periods.

- Nutrients are rapidly dispersed from the immediate site area and are diluted and assimilated. such that they never augment ambient nutrient levels above the EQS's set for these parameters. Thus, by definition, nutrients present no impact risk to invertebrates or flora.

- The organic standards applying limit the amount of medication and chemicals used on organic salmon farm sites . Experience has also shown that disease occurrence is reduced by organic culture standards and by the use of vaccines against the most common diseases. The use of well boats for bath treatment minimises the risks associated with soluble lice treatments. Deposition of in-feed lice treatments per m^2 will be minimised due to the low stocking density in the cages and resulting low deposition rate of solids. In the respect, the work of SEP and others, quoted in Section 6.2.2 is also referred to, which, on the basis of empirical data gathered at Scottish sea farm sites has found that that the impact risks to flora and fauna within the site area of farms and beyond due to lice medicines and chemicals is minimal.

5.3.3. Conservation measures; birds

The conservation measures applying in the vicinity of the Shot Head site were considered in Section 2.1.2. It was noted that the waters of Bantry Bay are not, as a whole, protected by any conservation measure. However there are numerous protection measures in place for terrestrial areas around the bay and one specific measure associated with a marine area, this being Glengarriff Harbour and Woodland, SAC and pNHA 000090. All conservation and protection designations in and around the bay area are shown in Figure 96. The Conservation Synopses for all protected areas around Bantry Bay can be found in Appendix 6.

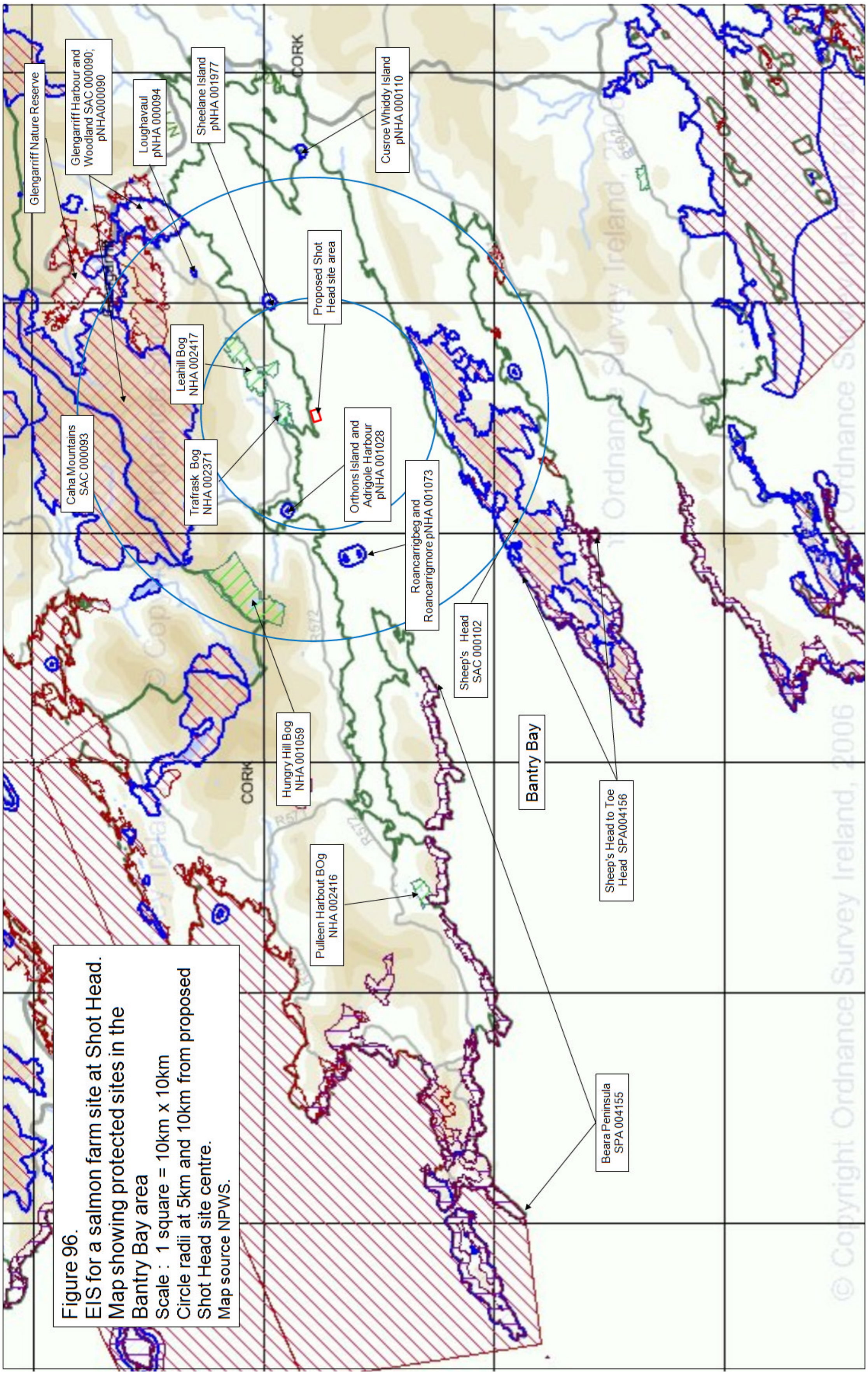


Figure 96.
EIS for a salmon farm site at Shot Head.
Map showing protected sites in the Bantry Bay area
Scale : 1 square = 10km x 10km
Circle radii at 5km and 10km from proposed Shot Head site centre.
Map source NPWS.

The western ends of the Beara Peninsula (SPA 004155), including much of the southern shore of Beara Island, and the Sheep's Head Peninsula (SPA 004156), are designated for their breeding bird populations, notably of Chough (*Pyrrhocorax pyrrhocorax*), Fulmar (*Fulmarus glacialis*) and Peregrine (*Falco peregrinus*), amongst others. Chough is a Red Data Book species[79], which, with the Peregrine, is also listed in Annex I of the EU Birds Directive. The western end of Sheep's Head also has SAC status (SAC 000102) for its dry and wet heath, both Annex II habitats and its population of the Annex II species, the Kerry slug, *Geomalacus maculosis*. However, these sites are terrestrial and a minimum of 10km from Shot Head. Their protected habitats and species are therefore at no risk of impact form the proposed operation.

There are a number of Annex I raised bog areas designated on the southern slopes of Beara, two of which are the closest designated sites to the proposed Shot Head site area, at Trafrask (NHA 002317) and Leahill (NHA002417). However, along with other terrestrial areas, such as the Caha Mountain SAC, even though some are quite close to Shot Head, their terrestrial nature would leave them isolated from the prospect of impact risks from the proposed salmon farming activity.

There are a several islands listed as pNHA's in Bantry Bay, all within 5 to 8km of the Shot Head area. These are Orthon's Island (pNHA 001028), Sheelane Island (pNHA 001977) and Roancarrigmore and Roancarrigbeg (pNHA 001073)[80]. These islands are all primarily designated for their populations of seabirds. Cusroe (pNHA 000110), 11km to the southwest of Whiddy Island is similar in this respect; see synopses in Appendix 6. In historical overview, these sites are used as breeding grounds by important populations of Cormorant (*Phalacrocorax carbo*), Shag (*Phalacrocorax aristotelis*), Herring Gull (*Larus argentatus*)and Lesser Black-Backed Gull (*Larus fuscus*), Arctic Tern (*Sterna paradisaea*) and Common Tern (*Larus Canus*). In the case of the Roancarrig Islands, these have been known to accommodate up to five breeding pairs of the rare and endangered Irish Red Data Book Species the Roseate Tern (*Sterna dugallii*) in the past. All tern species are listed in Annexe II of the EU Birds Directive. Orthon's Island is also noted for its haul out site for the common (harbour) seal (*Phoca vitulina*); see below.

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79 Chough is regarded as being of international importance, having undergone considerable declines over the last century or so, hence its red data book listing under the Birds Directive.

80 Note that the Roancarrig Island are no more than 1,500m from the MHI Roancarrig farm site.

Designated areas aside, Inner Bantry Bay is an important area for sea birds of many species in winter due to shelter that it offers[81] and all these are offered protection under the general terms of the Birds Directive, even if they are not accorded a specific protected status. The following list of species recorded in the area, either as residents (R) or over-winterers (W), is taken from the Bantry Bay Biodiversity Plan:-

Cormorant *Phalacrocorax carbo* R
Shag *Phalacrocorax aristotelis* R
Little Egret *Egretta garzetta* R
Grey Heron *Ardea cinerea* R
Oystercatcher *Haematopus ostralegus* R
Mediterranean Gull *Larus melanocephalus* W rare
Little Gull *Larus minutus* W
Black-headed Gull *Chroicocephalus ridibundus* R
Ring-billed Gull *Larus delawarensis* W rare but may breed here
Common Gull *Larus canus* R
Herring Gull *Larus argentatus* R
American Herring Gull *Larus smithsonianus* W rare in Ireland
Iceland Gull *Larus glaucoides* W scarce
Glaucous Gull *Larus hyperboreus* W scarce
Great Black-backed Gull *Larus marinus* R
Lesser Black-backed Gull *Larus fuscus* R
Kittiwake *Rissa tridactyla* R
Arctic Tern *Sterna paradisaea* S
Common Tern *Sterna hgirundo* R
Roseate tern *Sterna dugallii*
Black Guillemot *Cepphus grylle* R
Razorbill *Alca torda* S
Gannet *Morus bassanus* S
Fulmar *Fulmarus glacialis* R
Great northern diver *Gavia immer* W

There is no doubt that a variety of seabirds interact with salmon farm sites at a low level, in particular at dawn and dusk, when staff are absent. As discussed in Section 3.4.12, cormorants in particular can be persistent predators if adequate and secure protection measures, in particular bird nets, are not in place. On very rare occasions, heron and diving gannets my become trapped in bird nets. It could also be argued that gulls in particular, as well as some adventurous non-seabird species, such as the hooded crow (*Corvus cornix*) do become

81 Bantry Bay Biodiversity Plan. www.bantryt biodiversity.com.

more evident on farm sites if salmon feed is available to them. However, the advent of feed barges and the positioning of feed spreaders close to the water, beneath the protective cover of bird nets, prevents such activities.

A considerable number of non-marine bird species also inhabit the Bantry Bay area. The list given by the Bantry Bay Biodiversity Plan includes the following, which are resident or summer or winter visitors, as indicated by the postfix R, S or W:-

Chough R	Jackdaw R	Hooded crow R
Rook R	Little Grebe R FW	Little Egret R
Grey Heron R	Oystercatcher R	Mute Swan R
Widgeon W	Common Scoter W	Mallard R
Red-breasted Merganser W	Goosander W	Sparrowhawk
RKestrel R	Pheasant R	Moorhen R
Coot R	Oystercatcher R	Dunlin W
Ringed Plover W/R	Bar-tailed Godwit W	Curlew W/R
Redshank W	Greenshank W	Turnstone W/R
Wood Pigeon R	Collared Dove R	Snipe R
Cuckoo S	Long-eared owl R	Barn Owl R
Swift S	Swallow S	House Martin S
Kingfisher R	Meadow Pipit R	Skylark R
Rock Pipit R	Grey Wagtail R	Pied Wagtail R
Dunnock R	Robin R	Stonechat R
Wheatear S	Blackbird R	Fieldfare W
Song Thrush R	Mistle Thrush R	Redwing W
Dipper R	Blackcap S/R	Sedge Warbler
Grasshopper Warbler S	Willow Warbler R	Wren R
Chiffchaff S/R	Spotted Flycatcher S	Goldcrest R
Coat Tit R	Blue Tit R	Great Tit R
Long-tailed Tit R	Treecreeper R	Jackdaw R
Hooded Crow R	Raven R	Magpie R
Jay R	House Sparrow R	Starling R
Reed Bunting R	Chaffinch R	Goldfinch R
Greenfinch R	Siskin R	Linnet R
Lesser redpoll R	Bullfinch R	

In overview, it is submitted that, whilst a number of bird species, occupying either terrestrial and marine habitats on the lists provided, are specifically protected, either within designated breeding areas around the bay or within the protected status Annexes to the Birds Directive, neither the location nor the activities at the proposed Shot Head site are expected to impact on local bird populations for the reasons given. In the particular case of terrestrial habitat species, they are without exception too far removed from the site to be considered at risk at any level.

5.3.4. Conservation measures; terrestrial mammals.

The Bantry Bay Biodiversity Plan lists terrestrial mammals that are indigenous to the Bantry Bay area:-

Lesser Horseshoe Bat *Rhinolophus hipposideros*
Brown Long-eared Bat *Plecotus auritus*

Daubenton's Bat *Myotis daubentii*	Pipistrelle sp. *Pipistrellus* sp.
Leisler's Bat *Nyctalus leisleri*	Hedgehog *Erinaceus europaeus*
Fox *Vulpes vulpes*	Irish Stoat *Mustela erminea*
American Mink *Mustela vison*	Badger *Meles meles*
Otter *Lutra lutra*	Sika Deer *Cervus nippon*
Red Squirrel *Sciurus vulgaris*	Bank Vole *Clethrionomys*
glareolus	
Brown Rat *Rattus norvegicus*	House Mouse *Mus domesticus*
Wood Mouse *Apodemus sylvaticus*	Irish Hare *Lepus*
timidushibernicus	
Rabbit *Oryctolagus cuniculus*	

A number of these species, notably the Lesser Horseshoe Bat and the otter are listed in Annex II of the Habitats Directive, implying that they are protected where they occur within SAC areas. The otter is also protected under Annex IV of the Directive implying protection wherever it occurs. In addition, the badger, all bat species, all deer species, hare, hedgehog, otter, pine marten, red squirrel and stoat are mammals offered additional protection by the Wildlife Acts. A number of these terrestrial mammal species occur within the Glengarriff Harbour and Woodland SAC 000090 and in the Glengarriff Nature Reserve as well as elsewhere around the bay. However, their terrestrial habitat and distance, in general, from the proposed Shot Head site installation indicates that they would not be at any risk of impact.

5.3.5. Conservation measures; marine mammals.

See also Sections 2.1.2 and 3.4.11. A number of marine mammals are known to frequent Bantry Bay to a greater of lesser degree. The list provided by the Bantry Bay Biodiversity plan is as follows:-

Common (Harbour) Seal *Phoca vitulina*
Grey Seal *Halichoerus grypus*

Common Dolphin *Delphinus delphis*
Harbour Porpoise *Phocaena phocaena*
Bottle-nose Dolphin *Tursiops truncatus*
Risso's dolphin *Grampus grisseus*

Atlanitc white-sided dolphin *Lagynorhynchus acutus*
Pilot whale *Globicephala melas*
Minke Whale *Balaenoptera acutorostrata*
Northern Bottle-nose Whale *Hyperoodon ampullatus*
Fin whale *Balaenoptera physalus*
Killer whale *Orcinus orca*
Humpback whale *Megaptera novaeangliae*

The harbour seal is protected within the Glengarriff Harbour and Woodland SAC. All porpoise, dolphin, whale and seal species and the leatherback turtle are amongst those protected under the Wildlife Acts as well as being listed in Annex IV of the Habitats Directive.

Porpoise, whale and dolphin species are seen with varying regularity in Bantry Bay. A further number of less frequent Cetacean visitors is not listed; see also Section 2.1.2. With the exception of seals, in particular harbour (common) seals in this case, cetaceans have little or no history of direct association with fish farm installations, although some species, such as the common dolphin, and harbour porpoise will frequently swim alongside fish farm vessels. Of the impact risks listed in Section 5.4.1, the effects of noise on cetaceans is worth consideration. The only noises expected to arise from the proposed Shot Head installation would emanate from the heavily insulated generator room and from the feed dosing equipment on the feed barge, from the feed spreaders in each cage and vessel engines. These noises tend to be consistent, of middle register and quite low in decibel terms. As marine environments go, it is submitted that Bantry Bay is probably a moderately noisy environment, due mainly to marine traffic, some of which is very large (see Section 6.1). Against this background it is not felt that any impact risks arise from the noises associated with the proposed operation.

Since the wider environment of the bay is not expected to be degraded by the presence of, or emissions from the proposed fish farm (see, for example Section 5.4.2), no risk is predicted for passing cetaceans.

Inner Bantry Bay is one of Ireland's main haul-out areas for harbour (common) seals (*Phoca vitulina*). This species comes ashore at haul-out sites to give birth in June and to moult during July and August. It is protected within two designations in Bantry Bay, the Glengarriff Harbour and Woodland SAC and the Orthon's Island pNHA; see Figure 97. Note that the Orthon's Island haul-out is not marked on this map which reflects information collected in 2003. However another haul-out site in Adrigole Harbour is marked.

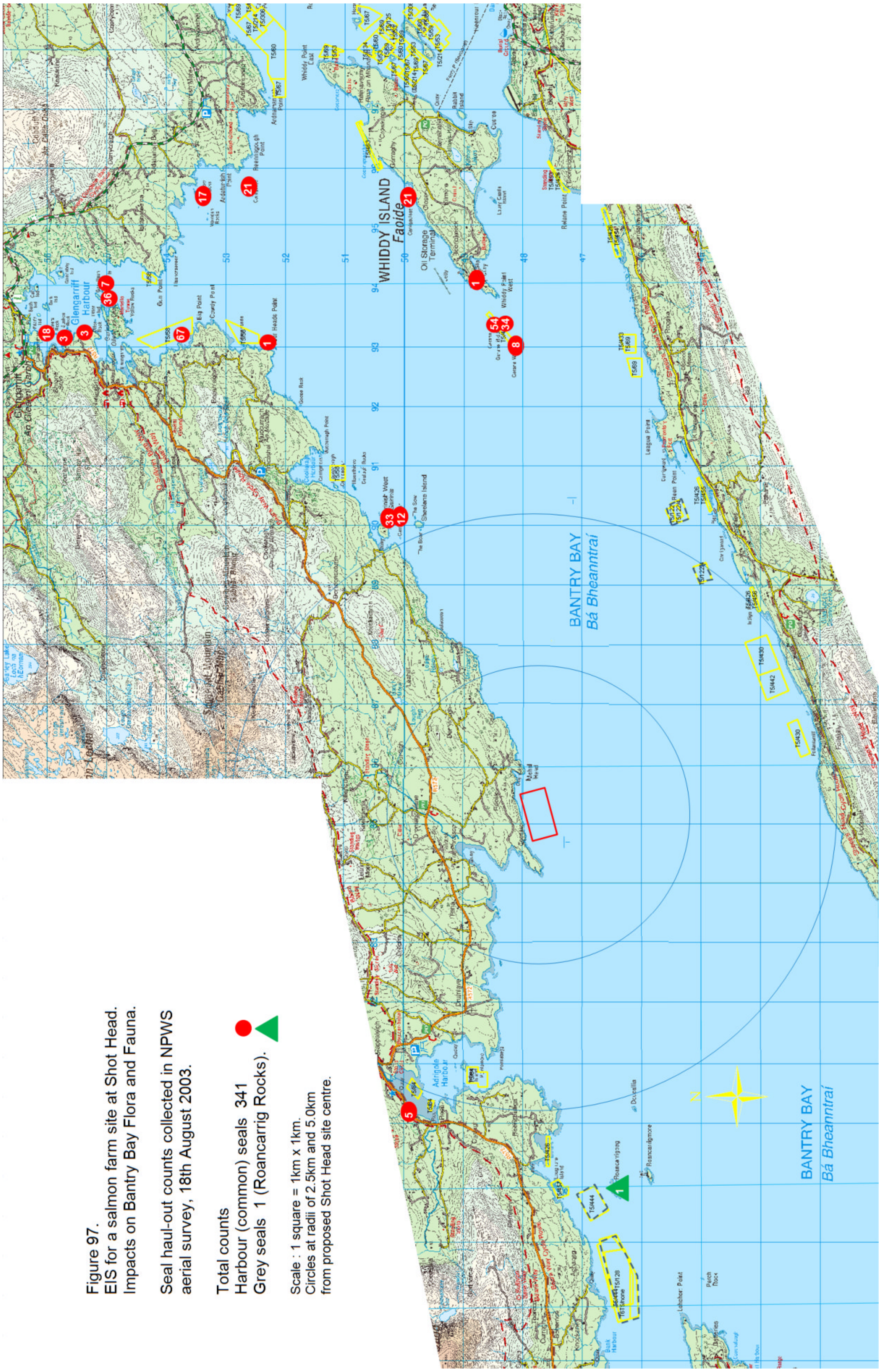

Figure 97.
EIS for a salmon farm site at Shot Head.
Impacts on Bantry Bay Flora and Fauna.

Seal haul-out counts collected in NPWS aerial survey, 18th August 2003.

Total counts
Harbour (common) seals 341
Grey seals 1 (Roancarrig Rocks).

Scale : 1 square = 1km x 1km.
Circles at radii of 2.5km and 5.0km from proposed Shot Head site centre.

To quote from the synopsis for the Glengarriff Harbour and Woodland SAC 000090 (see Appendix 6.2):-

The harbour supports mariculture (rope grown mussels) and tourism (boats visiting Garinish Island) industries. Neither activity appears to have affected seal numbers, although increased disturbance may pose a threat.[82]

It can be seen from Figure 97 that the registered common seal haul-outs closest to the proposed Shot Head site area are at Sheelane Island (pNHA 001977 although the synopsis does not mention the common seal) and at Orthon's Island / Adrigole Harbour (pNHA 1028). These are approximately 5km to the east and west of the site area respectively.

Grey seals (*Halychoerus grypus*) are much less common in Bantry Bay, preferring more exposed habitats further west. Only a single specimen was registered in the 2003 survey[83], at Roancarrig (Roancarrigmore and Roancarrigbeg pNHA 001073, although the synopsis for the site does not mention seals). Few grey seals have ever been seen in the inner bay.

Although there are many haul-out sites in the bay, they are at a considerable distance from the proposed site. Whilst there is no doubt that seals will visit the site on occasions, the distances to the haul-outs renders the risk of impact low.

5.3.6. Designated shellfish areas.

In addition to the measures taken to protect the natural environment, listed above, there are five Designated Shellfish Areas in Bantry Bay, designated under the Quality of Shellfish Waters Regulations 2006 (SI 268 of 2006) and Article 5 of EU Shellfish Directive, 2006/113/EC. The overriding majority of aquaculture licences for the growing of shellfish in Bantry Bay lie within these areas; see Figures 6 to 8. The Characterisation Report and Pollution Reduction Program Report for each of these areas, published in 2010[84], do not rank marine salmon farming or aquaculture in general in the bay as being a threat to the designation objectives of these areas.

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82 Taken from the Synopsis of the Glengarriff Harbour and Woodland SAC 000090.

83 Cronin M et al. 2004. Harbour seal population assessment in the Republic of Ireland 2003. Irish Wildlife Manuals No. 11. © National Parks and Wildlife Service.

Section 6.
Social and other interactions

6.1. The local economy.

Overall, in particular against a diminishing capture fisheries sector, aquaculture makes a growing contribution to Ireland's fisheries resource It will provide an increasing source of alternative employment in rural coastal areas if capture fisheries and agriculture continue to reduce in viability, as has been forecast. Aquaculture produce, a good proportion of it home grown, already makes up over 40% of Irish fresh fish retail sales.

It is expected that, if a licence is granted for the proposed Shot Head site, it will provide eight full-time jobs as well as considerable downstream employment, in particular in the handling, harvesting, live-hauling and packing, processing and marketing of the fish. Marine salmon farming also creates employment further afield, in such areas as chandlery, cage, vessel and net supply and maintenance, and the supply of salmon smolts and feed.

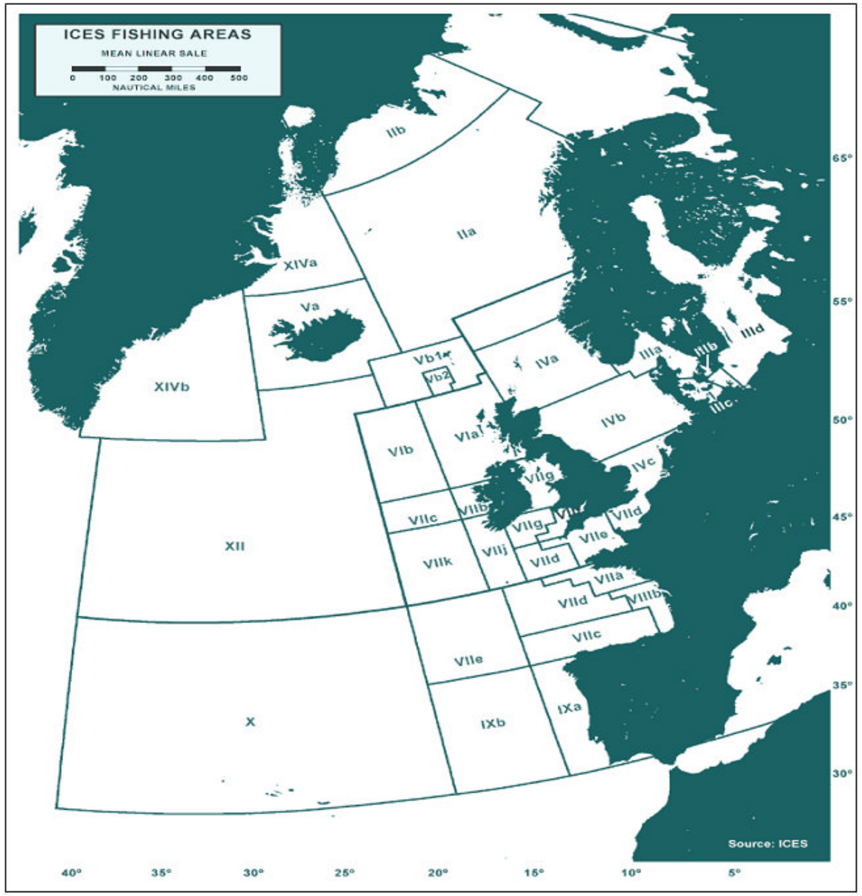
6.2. Impact on fishing

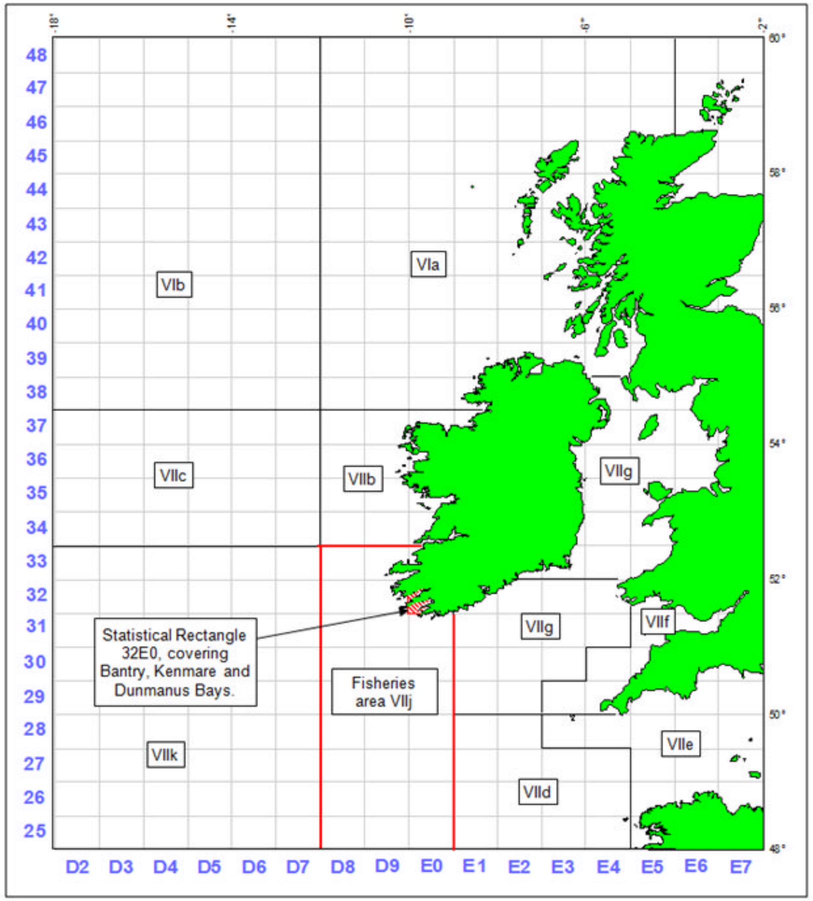
6.2.1. The commercial capture fishery.

Irish capture fisheries statistics are collected and collated by the Sea Fish Protection Authority (SFPA) and also by BIM, for their own use and for submission to the international fisheries database, maintained by the International Committee for the Exploration of the Sea (ICES). Data is collected on the basis of defined ICES Fishing Areas, shown in Figure 98. These are further subdivided into the smallest division, Statistical Rectangles, also shown in Figure 98. Bantry Bay lies in Statistical Rectangle 32E00, which also includes Kenmare Bay and Dunmanus Bay, within Fishing Area VIIJ, which includes the entirety of the South West of Ireland.

There are four ports in Bantry Bay for which fisheries data is available. These are Bantry, Castletownbere, Glengarriff and Leehanebeg, which is served by a small pier, some 14km to the west of Castletownbere. It is likely that there are other minor landings at other small piers around the bay. Fisheries data for these ports was provided for the period 2006 to 2009 by the SFPA although some of this data was incomplete. Where possible, the data was revised with updates from BIM. Data was available in two forms:-

Figure 98.
EIS for a salmon farm site at Shot Head.
Social interactions.
ICES Fishing Areas and statistical recatangles, used by national authorities for the collection of capture fisheries statistics.





- Landings by licensed fishery vessels of over 10m length. This is the offshore fishery and has no bearing on and would not be affected by the establishment of a salmon farm at Shot Head. Castletownbere is, to all intents and purposes, the only port for these landings in the bay, which are summarised in Table 1, in Section 2.1.4.

- Landings by vessels of under 10m in length. This is the inshore fishery. It is a reasonable assumption that the landings from these vessels at Bantry Bay ports and piers are caught within the bay waters. Since the inshore fishery exploits the wild fish stocks within the bay, this fishery must be considered in the context of the establishment of any aquaculture enterprise in the bay, including the proposed salmon farm at Shot Head. This matter was raised in two of the responses to the scoping study

Figure 99 shows the recorded annual inshore landings by main species and groups between 2006 and 2009 for the whole bay in terms of tonnage, total landed value and landed value per kg. The data are further broken down in Figures 99 and 100, to show the annual data for each of the four ports listed, as tonnage landed and total landed value.

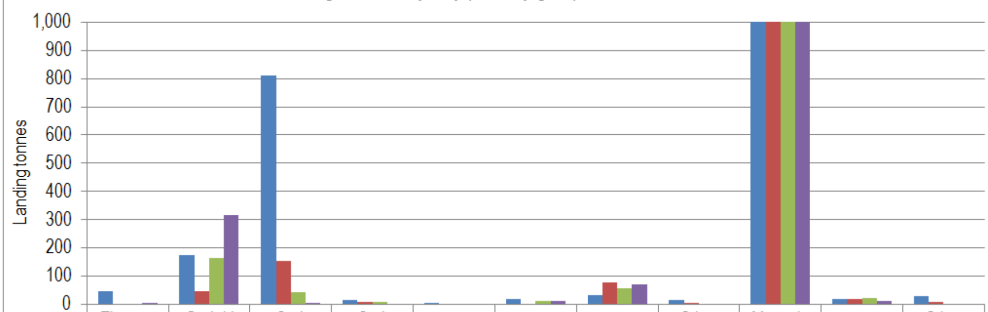
Although no longer historical database was available, it is assumed that inshore catches landed to Bantry Bay ports have been decreasing, as elsewhere throughout the North Sea area. It is nonetheless notable that the inshore fishery remains a valuable resource, with the total annual value of landings being of the range of €2.4M to €3.75Mpa.

However, notably, as Figure 99 shows, landings, both by tonnage and value are now dominated by rope mussels, which should rightfully be regarded as an aquaculture crop rather than an inshore fishery resource. There are about 8 individuals / groups involved in the mussel fishery. Note that the tonnage and value of mussels for Bantry, Castletownbere and Glengarriff are so high relative to other species caught that their values exceed the y-axes limits in Figures 99 to 101. Please note the maximum axis values and the data tables.

There are other aquaculture products landed in the bay ports, primarily at Castletownbere, which are not included in the statistics. The main one is farmed salmon, both from Fastnet Irish Seafoods sites and MHI Roancarrig. Until 2006, wild salmonids from the Bantry Bay driftnet fishery would also have made up a considerable proportion of the inshore catch but this ceased with the banning of salmon drift netting by statue from the end of the 2006 season (see also Section 5.2.1).

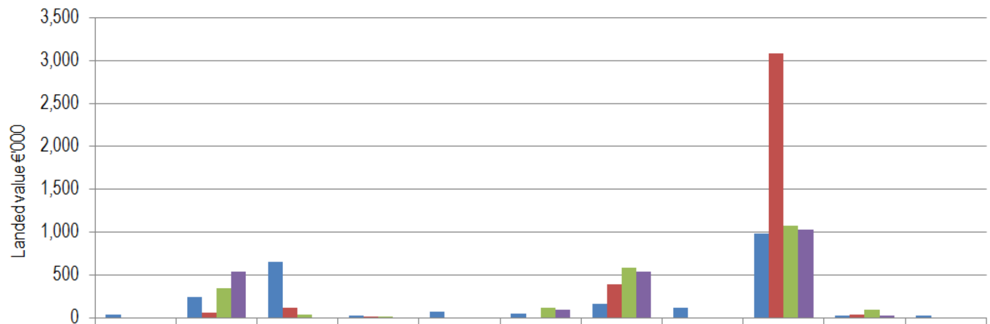
Figure 99.
EIS for a salmon farm site at Shot Head.
Social interactions.
Bantry Bay ports; inshore landings; tonnes by port and group per annum.
Note : Some columns off-scale (mainly mussel landings). Check vertical axes and data tables.

Total inshore landings for Bantry Bay ports by group; 2006 to 2009, landed tonnes.



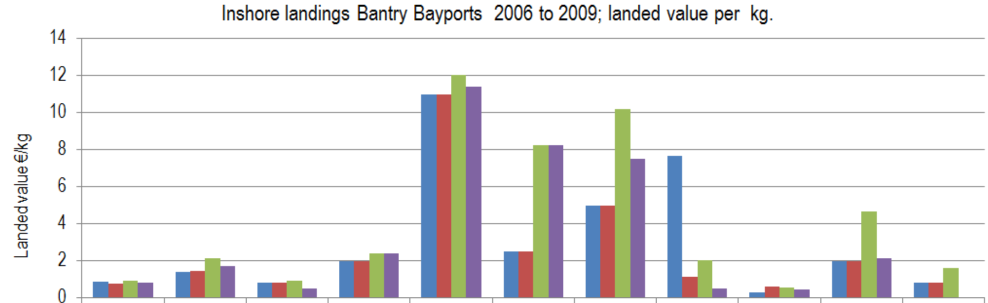
	Elasmo-branchs	Gadoid fish	Crab edible	Crab velvet	Lobsters	Nephrops	Shrimps	Other Arthropods	Mussels Blue	Scallop	Other Molluscs
2006	46.45	175.45	811.79	16.21	7.10	20.10	34.13	15.22	3,692.00	17.87	31.37
2007	2.35	48.64	155.08	8.30	0.95	2.48	79.60	4.70	4,903.00	18.40	8.50
2008	3.55	162.94	44.45	8.94	0.40	14.20	58.04	1.35	1,952.00	21.22	0.01
2009	4.15	317.31	4.29	0.99	0.35	12.06	71.93	0.60	2,393.00	12.10	0.00

Total inshore landings for Bantry Bay ports by group; 2006 to 2009; landed value €'000.



	Elasmo-branchs	Gadoid fish	Crab edible	Crab velvet	Lobsters	Nephrops	Shrimps	Other Arthropods	Mussels Blue	Scallop	Other Molluscs
2006	40.20	246.61	649.43	32.42	78.10	50.25	170.65	116.89	986.56	35.74	25.44
2007	1.84	69.35	124.06	16.60	10.45	6.20	398.00	5.28	3,076.55	36.80	6.80
2008	3.24	343.64	41.25	21.57	4.84	117.08	591.24	2.74	1,074.47	98.59	0.02
2009	3.42	537.12	2.13	2.39	4.02	99.43	538.62	0.30	1,028.40	26.04	0.00

Inshore landings Bantry Bayports 2006 to 2009; landed value per kg.



	Elasmo-branchs	Gadoid fish	Crab edible	Crab velvet	Lobsters	Nephrops	Shrimps	Other Arthropods	Mussels Blue	Scallop	Other Molluscs
2006	0.87	1.41	0.80	2.00	11.00	2.50	5.00	7.68	0.27	2.00	0.81
2007	0.78	1.43	0.80	2.00	11.00	2.50	5.00	1.12	0.63	2.00	0.80
2008	0.91	2.11	0.93	2.41	12.03	8.25	10.19	2.04	0.55	4.65	1.63
2009	0.82	1.69	0.50	2.40	11.41	8.25	7.49	0.50	0.43	2.15	0.00

Figures 99 and 100 illustrate that, with the possible exception of mussels, annual catches by group can be very variable. It is felt that this is more a reflection of capture effort being put into each group by the vessels concerned than a characteristic of the resource. Figure 101 breaks down the bay catch by port. Overall, Bantry tends to take the greatest proportion of the catch by weight, with Castletownbere and Glengarriff being fairly evenly matched. However because Bantry takes the greatest proportion of the mussel catch (being the nearest port to the greatest number of lines), as opposed to higher value shellfish, the greatest value of the inshore catch is landed at Castletownbere. Leehanebeg is something of an outlier in that it is in the mouth of the bay and the landings there reflect this, being mainly demersal and pelagic fish and some higher value shellfish species, from potting. Since the outer bay is too exposed for mussel culture, no mussels are landed into Leehanebeg.

Castletownbere is the next nearest port to the mouth of the bay and, therefore, also lands a large proportion of demersal and pelagic fish.

Higher value crustaceans and molluscs, namely lobster, shrimp, *Nephrops* and scallop only represent a relatively small proportion of the total landings by weight but their high unit value is translated into a high total value relative to some other landings.

Overall, shellfish (crustaceans and molluscs) form the mainstay of the Bantry Bay landed catch, although small quantities of demersal fish, such as dogfish (elasmobranches) and gadoids such as lemon sole, turbot, brill saithe and whiting are also landed.

6.2.2. Inshore fishing and the proposed Shot Head site

There has been a view that salmon farming has the potential to impinge on inshore fishing returns, through the siting of cages on or near fishing grounds. However it is submitted that this has not occurred in Irish waters to date. Stock depletion has arisen mainly as a result of over-fishing, before the introduction of salmon farming. It has also occurred in areas where there are no salmon farms. The main target for criticism has been the effect of sea lice treatments, in particular on crustaceans and on the larval stages of both crustaceans and molluscs, a number of which are either human food species or a dietary component of such species. However, in its 2005 report[85], Scottish Environmental Protection Agency (SEPA) concluded that:-

[85] Anon. 2005. The occurrence of the active ingredients of sea lice treatments in sediments adjacent to marine fish farms. Scottish environmental protection Agency (SEPA) www.sepa.org.

"*the 2001 and 2002 surveys have shown that, at the majority of fish farm sites sampled, the concentrations of active ingredients from approved sea lice treatments in the adjacent sediments were likely to be below SEPA's environmental standards and therefore resultant environmental impacts would not have been significant at any of these sites"*.

Similar sentiments were expressed in a report issued by the Scottish Association for Marine Science in 2005[86], with the statement:-

"The broad objective of the project was to determine the ecological effects of sea lice treatments in Scottish sea lochs, and in those terms that objective as been met, with no gross effects of medicines on the receiving environment distinguished. The project has achieved much by helping to improve our understanding of natural variability in relatively unstudied systems and, most especially, by demonstrating that wide-scale ecosystem-level effects from medicine use, if they exist at all, are likely to be of the same order of magnitude as natural variability and, therefore, inherently difficult to detect."

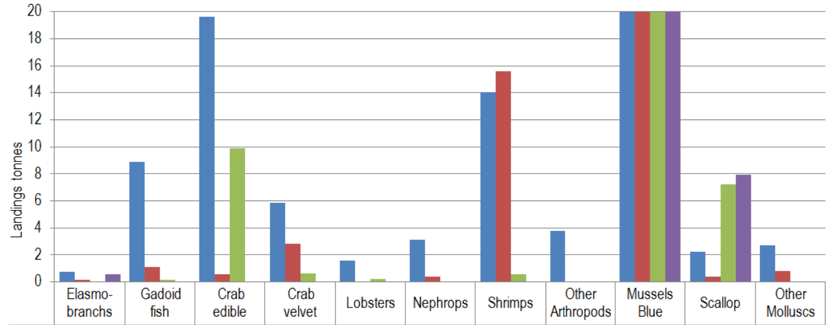
It is submitted that if this is situation in Scottish sea lochs, the same at least would be true in Irish coastal waters, since salmon farming is less intensive in Irish than in Scottish waters and Irish west coast bays are generally much better flushed than Scottish sea lochs and inshore waters. In the particular case of the Shot Head site, the low stocking density used, the use of well boats for sea lice bath treatments (not a standard practice at the time of writing of the SEPA report), lice treatment rotation and the reduction in the use of medication overall as a result of vaccination and adherence to organic standards all mitigate against local and far field impacts on wild fishery resources.

There remains only the issue of the impact of the physical presence of the proposed site on fishing in the locality. As far as is known, the immediate site area has only been exploited by a single vessel in recent years, engaged in shrimp potting. It is submitted that shrimp is a migratory species, with suitable grounds throughout mid and inner Bantry Bay. In addition, the immediate area around the cage installation could still be set with pots if so required.

[86] Chromey C., Nickell T., Wiullis K. (Eds.) 2005. Ecological effects of Sea Lice medicines in Scottish sea lochs. Report; Scottish Association for Marine Science, Plymouth Marine Laboratory, Fisheries Research Services, SEAS Ltd. 60 pages.

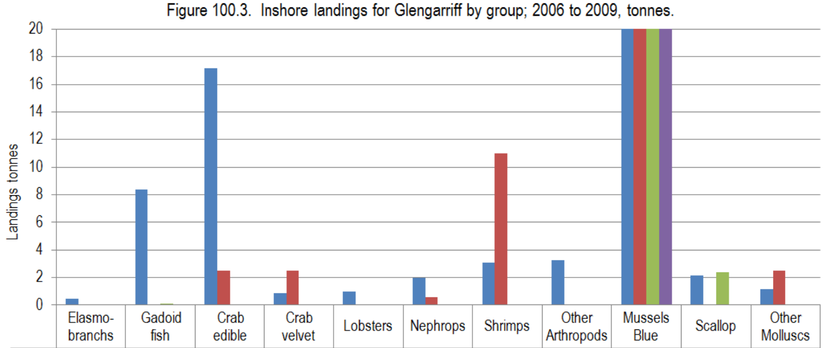
Figure 100.
EIS for a salmon farm site at Shot Head.
Social interactions.
Bantry Bay ports; inshore landings; tonnes by port and group per annum.
Note : Some columns off-scale (mainly mussel landings). Check vertical axes and data tables.

Figure 100.1. Inshore landings for Bantry Port by group; 2006 to 2009, tonnes.



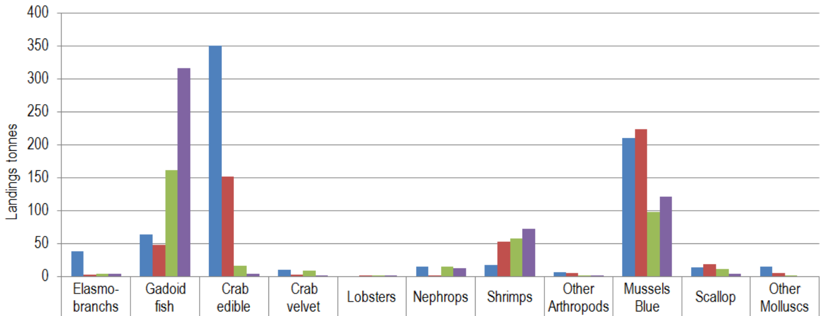
	Elasmo-branchs	Gadoid fish	Crab edible	Crab velvet	Lobsters	Nephrops	Shrimps	Other Arthropods	Mussels Blue	Scallop	Other Molluscs
2006	0.74	8.90	19.64	5.86	1.60	3.10	14.07	3.76	2,732.00	2.25	2.69
2007	0.16	1.11	0.58	2.80	0.05	0.38	15.60	0.00	3,580.00	0.40	0.80
2008	0.00	0.13	9.88	0.63	0.20	0.00	0.58	0.04	1,433.51	7.23	0.00
2009	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,757.37	7.90	0.00

Figure 100.3. Inshore landings for Glengarriff by group; 2006 to 2009, tonnes.



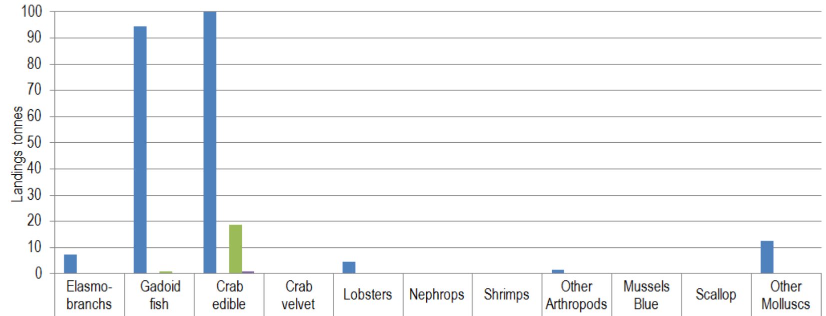
	Elasmo-branchs	Gadoid fish	Crab edible	Crab velvet	Lobsters	Nephrops	Shrimps	Other Arthropods	Mussels Blue	Scallop	Other Molluscs
2006	0.46	8.37	17.14	0.86	1.00	2.00	3.07	3.26	750.00	2.12	1.19
2007	0.00	0.00	2.50	2.50	0.00	0.60	11.00	0.00	1,100.00	0.00	2.50
2008	0.00	0.11	0.00	0.00	0.07	0.00	0.00	0.07	420.15	2.41	0.00
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	515.07	0.00	0.00

Figure 100.2. Inshore landings for Castletownbere Port by group; 2006 to 2009, tonnes.



	Elasmo-branchs	Gadoid fish	Crab edible	Crab velvet	Lobsters	Nephrops	Shrimps	Other Arthropods	Mussels Blue	Scallop	Other Molluscs
2006	37.75	63.62	350.00	9.50	0.00	15.00	17.00	6.70	210.00	13.50	15.00
2007	2.19	47.53	152.00	3.00	0.90	1.50	53.00	4.70	223.00	18.00	5.20
2008	3.55	161.74	15.87	8.31	0.10	14.20	57.45	1.09	98.34	11.59	0.01
2009	3.56	316.92	3.52	0.99	0.11	12.06	71.68	0.59	120.55	4.20	0.00

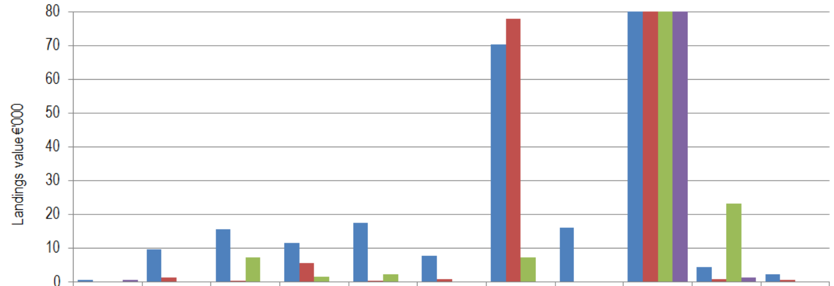
Figure 100.4. Inshore landings for Leehanebeg by group; 2006 to 2009, tonnes.



	Elasmo-branchs	Gadoid fish	Crab edible	Crab velvet	Lobsters	Nephrops	Shrimps	Other Arthropods	Mussels Blue	Scallop	Other Molluscs
2006	7.50	94.57	425.00	0.00	4.50	0.00	0.00	1.50	0.00	0.00	12.50
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.00	0.95	18.70	0.00	0.03	0.00	0.00	0.16	0.00	0.00	0.00
2009	0.00	0.39	0.78	0.00	0.25	0.00	0.26	0.01	0.00	0.00	0.00

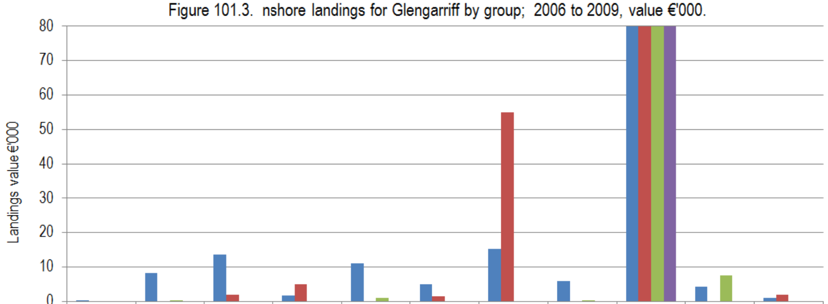
Figure 101.
EIS for a salmon farm site at Shot Head.
Social interactions.
Bantry Bay ports; inshore landings; value €'000 by port and group per annum.
Note : Some columns off-scale (mainly mussel landings). Check vertical axes and data tables.

Figure 101.3. Inshore landings for Bantry Port by group; 2006 to 2009, value €'000.



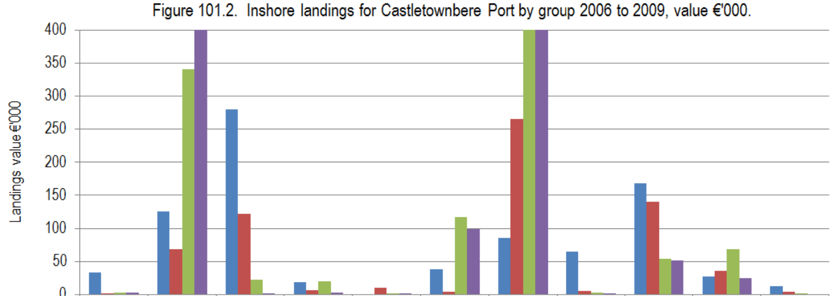
	Elasmo-branchs	Gadoid fish	Crab edible	Crab velvet	Lobsters	Nephrops	Shrimps	Other Arthropods	Mussels Blue	Scallop	Other Molluscs
2006	0.58	9.63	15.71	11.71	17.60	7.75	70.33	16.02	218.56	4.50	2.32
2007	0.13	1.43	0.46	5.60	0.55	0.95	78.00	0.00	2,246.39	0.80	0.64
2008	0.00	0.17	7.31	1.59	2.40	0.00	7.36	0.08	789.05	23.18	0.00
2009	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	755.24	1.43	0.00

Figure 101.3. nshore landings for Glengarriff by group; 2006 to 2009, value €'000.



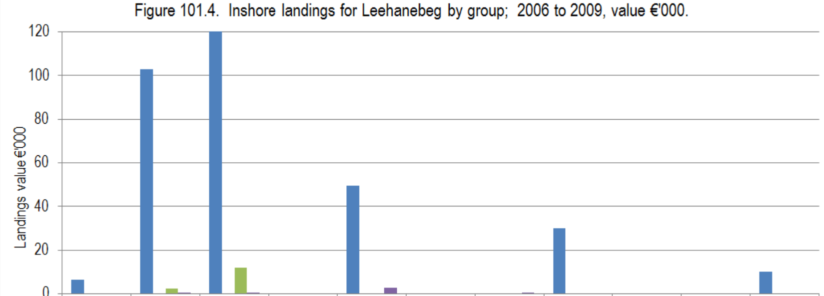
	Elasmo-branchs	Gadoid fish	Crab edible	Crab velvet	Lobsters	Nephrops	Shrimps	Other Arthropods	Mussels Blue	Scallop	Other Molluscs
2006	0.36	8.15	13.71	1.71	11.00	5.00	15.33	6.02	600.00	4.24	1.12
2007	0.00	0.00	2.00	5.00	0.00	1.50	55.00	0.00	690.23	0.00	2.00
2008	0.00	0.18	0.00	0.00	0.93	0.00	0.00	0.03	231.27	7.51	0.00
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	221.35	0.00	0.00

Figure 101.2. Inshore landings for Castletownbere Port by group 2006 to 2009, value €'000.



	Elasmo-branchs	Gadoid fish	Crab edible	Crab velvet	Lobsters	Nephrops	Shrimps	Other Arthropods	Mussels Blue	Scallop	Other Molluscs
2006	32.66	125.95	280.00	19.00	0.00	37.50	85.00	64.84	168.00	27.00	12.00
2007	1.71	67.92	121.60	6.00	9.90	3.75	265.00	5.28	139.93	36.00	4.16
2008	3.24	340.84	21.79	19.98	1.20	117.08	583.88	2.56	54.13	67.90	0.02
2009	2.74	536.60	1.44	2.39	1.25	99.43	537.98	0.29	51.81	24.62	0.00

Figure 101.4. Inshore landings for Leehanebeg by group; 2006 to 2009, value €'000.



	Elasmo-branchs	Gadoid fish	Crab edible	Crab velvet	Lobsters	Nephrops	Shrimps	Other Arthropods	Mussels Blue	Scallop	Other Molluscs
2006	6.60	102.88	340.00	0.00	49.50	0.00	0.00	30.00	0.00	0.00	10.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.00	2.46	12.16	0.00	0.32	0.00	0.00	0.08	0.00	0.00	0.00
2009	0.00	0.52	0.70	0.00	2.77	0.00	0.63	0.00	0.00	0.00	0.00

Other species which may have inhabited the area are *Nephrops* and scallop. During ROV surveys of the seabed (see Section 2.12), no scallop were seen at all. Whilst *Nephrops* was clearly present, burrow complexes seemed to be at too low a density for economic exploitation. This is borne out to some degree by the absence of dredging tracks on the seabed in the area indicating that fisheries for *Nephrops* or scallop have not been exploited there at least in recent times.

6.2.3. Sea Angling

See also Section 2.1.5 and Figure 12, which indicates a recommended shore angling station at Shot Head Bearing in mind nature and extent of water column and benthic impacts along with other impacts quantified an qualified in this EIS, there are no indications of any likely impact on this pursuit, arising as a result of the proposed activity.

6.3. Visual impact

6.3.1. Introduction

An unpolluted, well-flushed marine environment and the ready availability of fisheries infrastructure and skills, plus availability of labour make the Irish coastline, from the southwest to north, one of the best in Europe for the development of a marine cage farming industry. By more than a little coincidence, these rural areas also possess some of the best coastal scenery in Europe and the majority of Ireland’s inshore and game fishery resources. Thus, as well as attracting a marine farming industry, this mix of attributes also attracts tourists and associated developments, along with required service industries, into Ireland's rural, coastal communities. However, it is only in recent times that Ireland has looked towards the preservation and enhancement of its natural heritage and, to count visual amenity high on this agenda.

Although Bantry Bay is a "working" bay, with many resource-based stakeholders, it is also an area of considerable scenic beauty, with much of its coastline deemed of scenic importance. Consequently the siting of new aquaculture facilities can be considered a sensitive issue. The Cork County Development Plan 2009 seven scenic routes with views across Bantry Bay. All have a landscape type designated Type 4; described as "*Rugged Ridge Peninsulas*" by the plan. These routes are listed below. Those with views that may encompass the proposed Shot Head site area (subject to lie of the land and vegetation) are marked with an asterisk.

Scenic Route S109*.
Local Roads around Caher Mountain and to Sheep's Head. Views of Dunmanus Bay, Bantry Bay, Atlantic Ocean, Sheep's Head, Bear Island and Ballyroon, Caher and Seefin Mountains. Type 4 landscape.

Scenic Route S110*.
Local Roads from Bantry to Kilcrohane, Ahakista and Clashadoo. Views of Dunmanus Bay and Bantry Bay, Whiddy Island, Caher, Seefin, Gouladane, Knockboolteenagh, Adrigole, Glenlough and Sugarloaf Mountains, Hungry Hill, Bear Island and the Beara Penninsula. Type 4 landscape.

Scenic Route S111.
N71 National Secondary Road from Bantry to Ballylickey and Glengarriff. Views of Bantry Bay, Whiddy Island, Glengarriff Harbour and Mullaghmesha, Sheehy, Coomhola and Cobduff Mountains. Type 4 landscape.

Scenic Route S112.
N71 National Secondary Road from Glengarriff to Kenmare (County Bounds). Views of Glengarriff Harbour and Barraboy, Esk and Caha Mountains. Type 4 landscape.

Scenic Route S113*.
R572 Regional Road between Glengariff, Trafrask, Ardrigole and Castletownbere. Views of Glengarriff Harbour, Bantry Bay, Whiddy and Bear Islands, Bear Haven, Shrone and Hungry Hills, and the Gowlbeg, Sugarloaf, Caha, Adrigole and Slieve Miskish Mountains. Type 4 landscape.

Scenic Route S114.
R574 Regional Road from Adrigole to Healy Pass. Views of Adrigole Harbour and Adrigole, Glenlough and Caha Mountains and Hungry Hill. Type 4 landscape.

Scenic Route S118.
R572 Regional Road from Castletownbere via Cahermore to Garnish. Views of Bear Haven, Bear Island, Firkeel Bay, Dursey Sound and Island, the sea, Slieve Miskish Mountains and surrounding hills. Type 4 landscape.

Thus the only scenic routes which may include vantage points encompassing the proposed Shot Head site area are routes S109 and

110, along local roads on the Sheep's Head Peninsula and route 113, along the R572, the main road between Glengarriff and Castletownbere. These routes are shown on the landscape map of the Bantry Bay area, in Figure 102, abstracted from the 2009 County Development Plan. The proposed Shot Head site area has been highlighted on this map. It will be noted from Figure 102 that the landscape in the immediate Shot Head area is not included in the scenic category, which applies both to the east and the west of it.

6.3.2. Landscape and visual impact assessment.

The proposed Shot Head site area at is situated on the north shore of Bantry Bay, close to the base of cliffs of low to medium height. It is in a sparsely populated part of Bantry Bay, where the width of the bay and local topography offer very few vantage points from which the proposed development will be visible.

In order to make a landscape and visual impact assessment of the proposed development, large orange buoys were deployed at the 4 corners and at the centre of the proposed site area. Digital photographs were then taken, looking towards the proposed location from all vantage points that could be found around the bay up to a distance of about 10km from the site. The lens used on the camera was a standard 50mm lens as required by the DAFF guidelines for visual impact assessment[87]. Where a possible visual impact was predicted, the image of the given view was digitally overlaid with a montage of the visible structures at the proposed development. Where necessary "before and after" views of the site area are then reproduced.; see Plates 31 to 35.

Figure 103 shows a map of the area within which the site may be visible. Vantage points are marked and labelled on the map. Stretches of road from which the site is visible are marked in green whilst those from which it is not visible are marked in red. A circular visual envelope with a radius of 5km is also superimposed on the map. Generally speaking, fish farm installations are extremely difficult to see beyond this range, in particular at low viewing angles and in dull weather, unless the viewer is very familiar with the local terrain. The coordinates of the vantage points are given in Table 28 and details follow.

87 Assessing the landscape and visualioact of marine salmon operations. DAFF 2001.

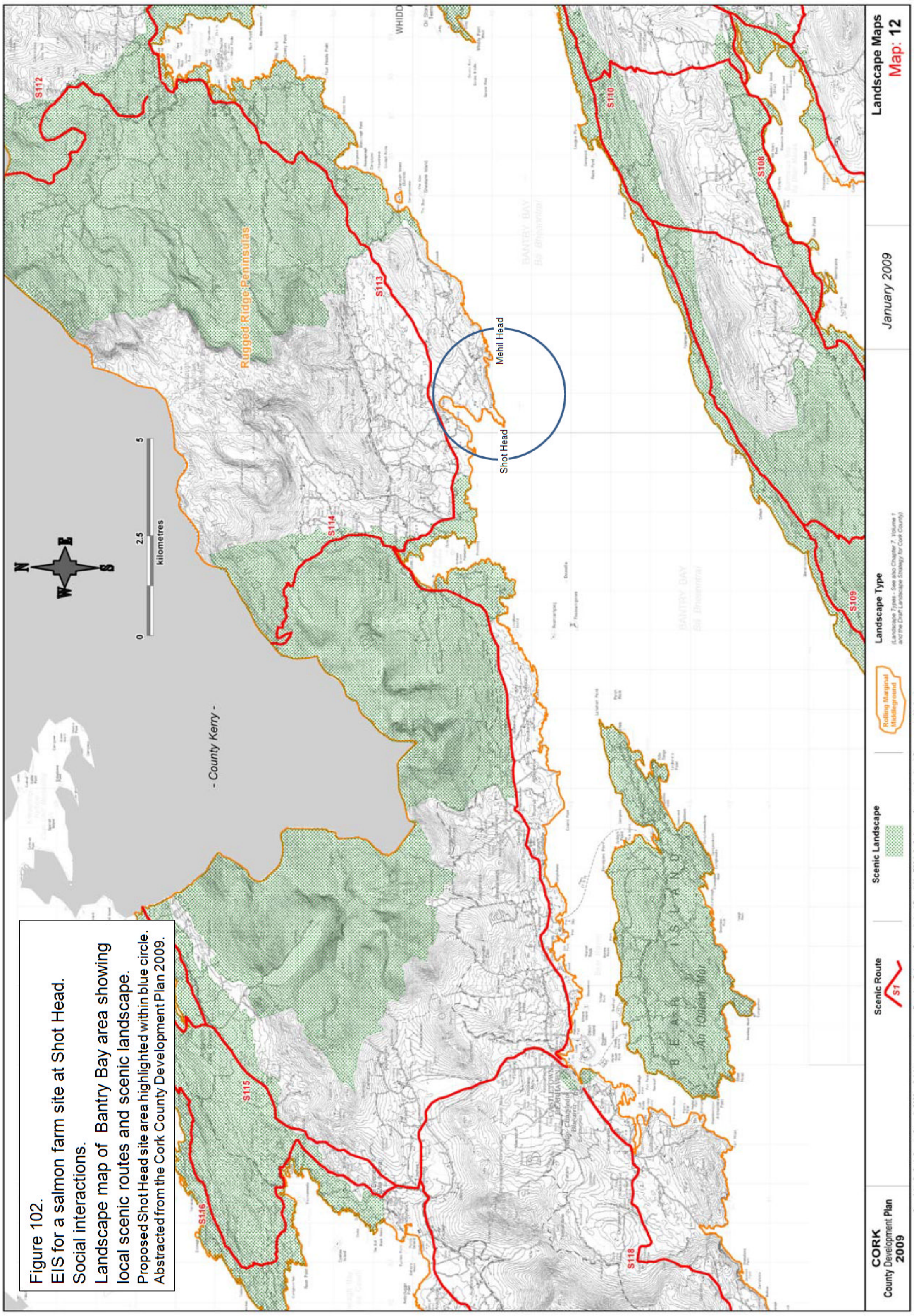


Figure 102.
EIS for a salmon farm site at Shot Head.
Social interactions.
Landscape map of Bantry Bay area showing local scenic routes and scenic landscape.
Proposed Shot Head site area highlighted within blue circle.
Abstracted from the Cork County Development Plan 2009.

Table 28.
EIS for a salmon farm site at Shot Head.
Social interactions.
Visual impact assessment; coordinates of Vantage Points.

Vantage Point	Location	WGS 84		Irish National Grid	
		Lat	Long	E	N
A	Road above site, Roosk.	51° 40.548'	-9° 38.998'	85882.24	48350.52
B	South shore, lay-by on road	51° 37.718'	-9° 38.191'	86694.53	43045.33
C	Layby on R572 west of site	51° 40.271'	-9° 45.230'	28686.04	47967.79
D	West end, Bear Island	51° 38.528'	-9° 47.401'	76103.78	44795.71

Vantage point A.
See Figure 103 and Plates 31 to 33. The site is not visible at close range from any point on the main R572 road which passes the site area at a distance of some 1.7km at its closest. The site is however just visible from this road, for a short stretch, at a distance; see Vantage Point C. A minor, largely single track road leaves the R572, sign-posted Trafrask and passes somewhat closer to the site area. This road makes a loop, passing Trafrask Pier and rejoins the R572. A narrow spur road branches from the loop and runs south towards Mehal Head, through the hamlet of Roosk. This serves three houses, one of which, at the end of the road, in unfinished. A second house is not permanently occupied whilst the third is occupied. It is possible to see part or all of the site looking south-west from the area near the end of the spur road, as shown in Plate 31.

The site is not visible for the other houses in the hamlet. This vantage point gives a very clear view of the site indeed, first of all because the viewing angle is enhanced by the height of the cliff at Mehal Head and secondly because the nearest cages are only about 700m from the observer. However, this is not a regularly frequented road, either by vehicular or foot traffic and the view only applies to a single property, which at least for the present is not permanently occupied.

Note that the Beara-Breifne Cycle Way passes along the R572 between Trafrask and Glengarriff whilst the Beara-Breifne Way (Beara Way) walking route passes some 1.5km to the north of the R572 and 3.2 km north of the proposed site area at an altitude of 500m. This is marked on Figure 103 as a hatched red line and is also shown in Figure 11. Although the view from the Beara Way is high, the proposed site cannot be seen in this area due to local topography. In contrast, the MHI Roancarrig site is readily visible from both the Beara Way and the R572 at a number of points between Adrigole and Castletownbere.

Vantage Point B

See Plate 34. Because the site is so difficult to see from this point, the image is only shown with the site features montaged onto it, albeit barely visible. Vantage Point B is on the southern shore, opposite the proposed site, where there is a potential view from the Goats Path coastal road. The road is also the route for the Sheep's Head Cycle Way. It passes down the Sheep's Head Peninsula close to the shore, at an altitude of no more than 30m above sea level along the stretches nearest to Shot Head; see Figure 104. However, views along this road are at a distance of some 5km and at a very shallow viewing angle. As a result the proposed site area is barely visible, even in good conditions, to all but the most experienced eye.

The Sheep's Head Way walking route also passes along the north side of Sheep's Head, at a maximum altitude of some 150m. The proposed site area can be seen at a higher viewing angle from this path but it is at a greater distance than from the coastal road and very difficult to make out.

There are two licensed salmon farm sites operated by Fastnet Irish Seafood and numerous shellfish sites situated along the north shore of Sheep's Head, no more than 900m from the coast road and 2.2km from the Sheep's Head Way. Relative to the Shot Head site these sites are easy to view from these routes, especially in the area of Gearhies; see in particular Figures 8 and 104

Going east along the Goat's path, the road turns inland. Views down the bay also become obscured by Whiddy Island. Although mussel lines are a common site in sea from the N71 road around the towns of Bantry and Glengarriff, views towards Shot Head itself are obscured by either vegetation or topography.

Vantage Point C.

As pointed out above, there are no views of the site area from the N71 or from the R572, (that branches off it in Glengarriff) as it passes the site. However there are distant (6km or more) and partially obscured views east towards Shot Head from a 500m stretch of the R572 west of Adrigole and from the Beara Way walking route, which runs above the road in this section. This area is designated Vantage Point C in Figure 103 and in Plate 35. However it should be said that viewing is fleeting and difficult from this vantage point, from which the site area itself is distant and obscured for the most part by Shot Head. In addition to this the viewing angle is low.

Figure 103 and Plate 31.
EIS for a salmon farm site at Shot Head.
Social interactions.
Visual impact assessment; view from Vantage Point A.

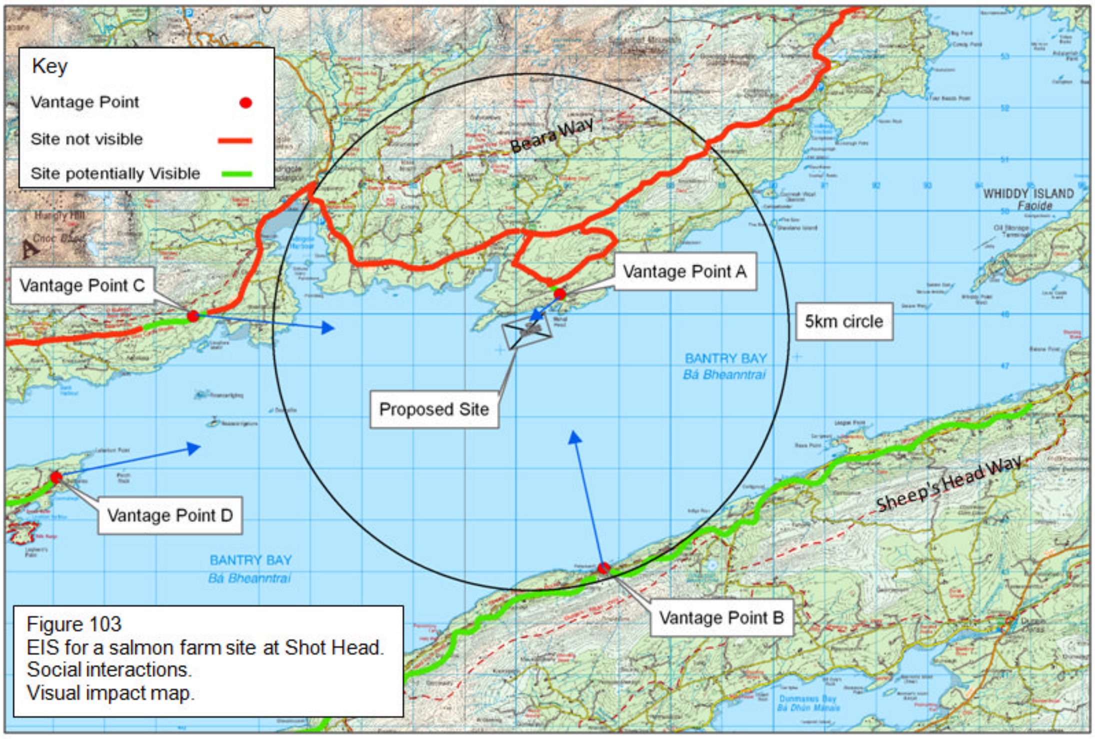


Plate 31. Vantage Point A; the single track road leading towards Mehia Head, which serves some three houses. There is a partially-built house, out of frame to the right, from which the site is not visible. The site is partially or fully visible, as marked by yellow arrows, from the road, from the rough pasture which runs down to the cliff at Mehal Head and from the house left of frame, which is not permanently occupied at present.

Plates 32 and 33.
EIS for a salmon farm site at Shot Head.
Social interactions.
Visual impact assessment; view from Vantage Point A.

Plate 32. Looking SW over the cliff from rough pasture above Mehil Head (see Plate 31). The end of the Sheep's Head Penisula can be seen in the distant background.

Plate 33. As Plate 32, with the cages and a feed barge at the proposed Shot Head site digitally superimposed onto the image.

Vantage Point D

The view from Vantage Point D is shown in Plate 36. This is towards the eastern end of Bear Island, some 10km from the proposed site. Although Shot Head is just visible in good weather, it would not be possible to see the proposed fish farm at this distance and viewing angle. Plate 36 indicates that Roancarrigmore lighthouse is readily visible at a distance of some 3.2km. Cages at the MHI Roancarrig salmon farm grower site are also visible, at a distance of about 3km.

6.3.3. Discussion

To all intents and purposes, the Shot Head site will only be very visible as a “foreground object” from a single, rarely frequented coastal vantage point and a single property, in the hamlet of Roosk.

There will be long-range to very long range views of visible structures at the proposed site, some partially obscured, from a maximum three locations but these are all over 5km away from the site area and, for the most part, from low viewing angles. Much the same applies to views from walking routes in the area which, although possessing a higher aspect are further away than related views from roads. Of all the salmon and shellfish farm sites in Bantry Bay, the proposed Shot Head site would be the least obtrusive on local views. Overall, therefore, the visual impact of the Shot Head site on its environs, the scenic value of which is fully acknowledged, is expected to be slight.

In areas as scenic as the Southwest of Ireland, location and visual impact can, understandably, be all-important issues. The matter of siting of coastal fish farms was addressed in a Scottish Natural Heritage publication in 2000. This emphasises the following criteria:-

- The need to identify appropriate locations for development.
- The need for all developments to respect the diversity of landscape character and to sustain the qualities, which reinforce experience of place.
- Aquaculture need not be hidden from view but should be well enough sited and designed to fit in with the surrounding character and contribute to a lived-in landscape.

In May 2001, the then Department of Marine and Natural Resources published its *Guidelines for Landscape and Visual Impact Assessment of Marine Aquaculture*, which expressed much the same sentiments.

Plate 34 and Figure 104.
EIS for a salmon farm site at Shot Head.
Social interactions.
Visual impact assessment; view from Vantage Point B.

Plate 34. View from Vantage Point B, on the Goat's Path Road on the south shore, 5km distant and at a very low viewing angle. Shot Head is left of the arrow.

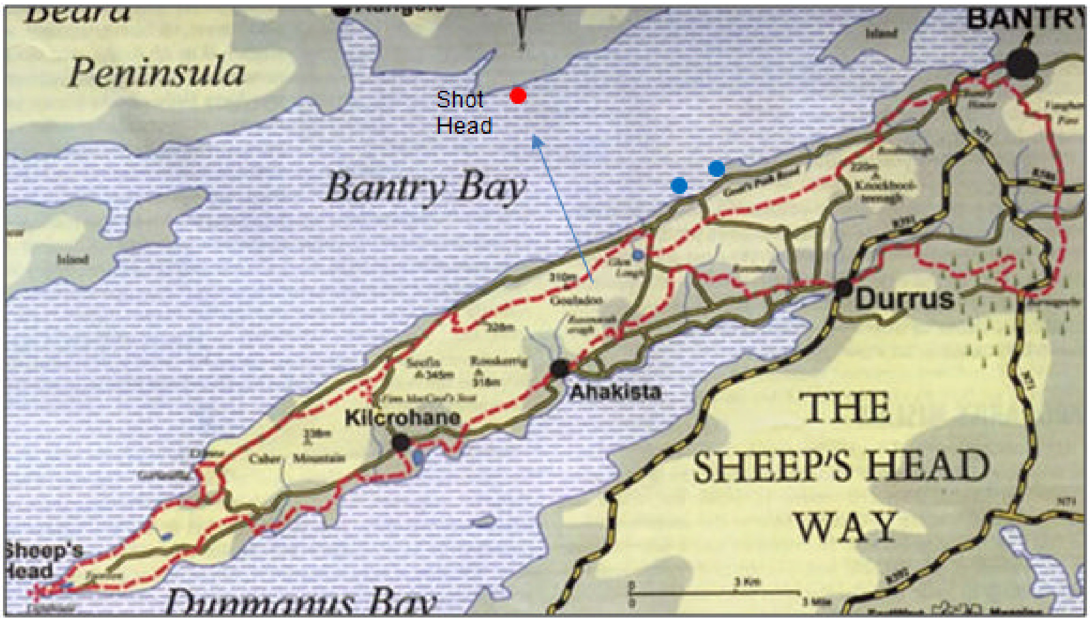


Figure 104. Sheep's Head Way walking route, which runs some 500m above the Goat's Path coastal road, opposite to and some 5km across Bantry Bay from the proposed Shot Head site area is marked with a red dot. The existing Fastnet Irish Seafood salmon farm sites are marked with blue dots.

Plates 35 and 36.
EIS for a salmon farm site at Shot Head.
Social interactions.
Visual impact assessment; views from Vantage Point C and D.

Plate 35. View from Vantage Point C, on the R572, west of Adrigole Harbour, looking east, some 6km from the proposed site, which is obscured by Shot Head.

Plate 36. View from Vantage Point D, at the East end of Bere Island, above the Battery. Roancarrigmore Lighthouse is mid-frame, at a distance of 3.2km. Cages at MHI Roancarrig can just by discerned inshore of the lighthouse, at a distance of 3km (in green circle). The proposed site is at a distance of approximately 10km and not visible at this distance and viewing angle.

Such criteria clearly give a basis for the location of fish farms in such areas but focus on the sensitivity that must be exercised in the matters of location and layout. The aspiration is that a reasonable and acceptable balance can be struck between the level of visual and other impacts created by a development and the benefits of its presence to the community, <u>in the majority view</u>. It is submitted that this balance has been struck by the size, structure and siting of the proposed Shot Head site, within the lived-in landscape of Bantry Bay, its seascapes and landscapes.

MHI undertakes to continue to make every effort to maintain this state of affairs should the licence now applied be granted. As set out elsewhere in this document, this will be achieved by:-

- Appropriate siting arrangements and orientation of main structures.
- The use of underwater mooring systems, which minimise surface structures.
- The use of muted colours wherever possible and practical for floating structures (including vessels), top-nets and fence-nets.
- A policy of tidiness, to be maintained in all areas, especially those in public view.
- Minimisation of traffic on public ways, such as piers and roads, for example by the use of well boats for fish transport and feed delivery by sea.

6.4. Other aquaculture

See also Section 2.1.4 and Figures 6 to 8. Relative to some other areas around the British Isles and Europe, aquaculture density is quite widely dispersed throughout Bantry Bay. Other aquaculture is not present to any great extent in the immediate vicinity of Shot Head, the nearest being some shellfish sites within the Bantry Bay South Designated Shellfish Area, which are 4.5km to the south, along the Sheep's Head shore; see Figure 9. As detailed in Section 5.1.4 and Figure 79, the only other licensed salmon farm sites in the bay are:-

- Fastnet Irish Seafood; two sites; 5.0 and 5.5km south east of Shot Head.
- MHI Roancarrig; 8km west of Shot Head.

The combined effects of discharges from these sites and the proposed Shot Head site are considered Section 4.6 whilst the effects of natural flushing on these is estimated in Section 4.7. This concludes that the combined impacts of all salon farm sites in the bay, both currently licensed and proposed, are of no consequence relative to the oceanic flux through the bay. The other salmon farming sites in the bay are at sufficient geographic and hydrographic distance from the proposed Shot Head site area that no augmentation of combined impacts is likely to occur.

The synchronous operation of all sites under the Single Bay Management and the distances between the sites can be expected to mitigate against risks of cross infection or infestation.

No other impact or deleterious consequence is expected to arise as a result of the number of farms in the bay, if a license for the proposed Shot Head is granted.

By way of further observation, there is now global interest in the development of Integrated Multi-Trophic Aquaculture (IMTA)[88], by which means the by-products, including waste, from one aquaculture species are used as inputs for the culture of others. For example, mussels and kelp have been growing adjacent to fed Atlantic salmon cages in the Bay of Fundy, Canada for a number of years. In this case, the kelp farm is assimilating soluble nitrogenous and phosphorus discharges from salmon culture, from which the mussels also utilise suspended solids. Phytoplankton, arising from primary production, also stimulated by soluble nutrients discharged by the salmon farm are also utilised by the mussels. This enterprise has been monitored since 2001 for contamination by medicines, heavy metals, arsenic, PCBs and pesticides. Concentrations are consistently either non-detectable or well below regulatory limits established by the Canadian Food Inspection Agency, the United States Food and Drug Administration and European Community Directives. Taste testers indicate that mussels produced in this way are free of "fishy" taste and aroma and could not be distinguished from "wild" mussels. Mussel meat yield is also significantly higher, reflecting the increase in nutrient availability. Such circumstances pertain in Bantry Bay which could, with closer cooperation between stakeholders, be operated on IMTA principles. By this means, nutrients and other waste streams could be profitably utilised and exported from the bay in marine produce, rather than left to increase their ambient concentration in bay waters.

88 See, for example, www.en.wikipedia.org/Integrated_Multi-Trophic_Aquaculture.

6.5. Other navigation

Four respondents expressed concern or requested further information about the proposed Shot Head farm operation in the scoping study for this EIS, in the context of navigation. The full scoping correspondence is appended in Appendix 1 of this document but the relevant sections of the four responses are as follows:-

Aiden McCarthy, Chairman, Bantry Bay Harbour Commissioners:-
"I wish to advise you that Bantry Harbour Authority would have concerns regarding the location of an aquaculture development in this area. The matter will be discussed at the next meeting of the Board and I will convey any further comments to you." [89]

Brian A Shaw, Estates Manager, Tarmac Ltd:-
"The vast majority of the product from Leahill Quarry leaves the site by sea and of course all the shipping related to the quarry passes the proposed location of your new salmon farm.......Obviously Tarmac Fleming is very concerned about how any possible conflicts between our businesses could be overcome and in particular that it should impact on the ability to export product by sea."

John Hunt, Bantry Bay Pilotage, Slip Park, Bantry:-
"I would consider the location that you have picked to be most unsuitable for the following reasons. 1. It is the anchorage for large tankers and bulk carriers since 1968. 2. The Leahill Jetty. Ships of 96,000 tonnes and 250m long are berthed there and your cages would be on their approach to the jetty if they are berthed port side to the jetty."

Captain Barry O'Driscoll, Conoco Philips, Bantry Bay Terminal, Reenrour, Bantry:-.
"We consider the location of the aquaculture development at Shot Head to be inappropriate due to its proximity to our deepwater anchorage for tankers. Tugs and other support vessels also operate in this area. This development would be an added hazard in the bay."

The Bantry Bay Harbour Authority Area is the area east of an imaginary line drawn between Crow Head and Sheep's Head, at the seaward end of Bantry Bay, excepting the waters of Berehaven Sound, between Ardkinna Point and the Roancarrigmore Lighthouse, including the Fisheries Harbour Centre at Castletownbere, which make up the Castletownbere Harbour Authority Area.

89 No further comments were communicated.

The inner harbour area of Bantry Bay is the area east of a line between Shot Head and the south shore of the bay. Thus the MHI Roancarrig site lies in the Castletownbere Harbour Authority Area. Navigation and other activities within the Bantry Bay Harbour Authority Area, including aquaculture, are covered by specific byelaws, adopted by the Harbour Commissioners in October 2010. Whilst these bye-laws do not supersede national law, they do incorporate considerable powers of enforcement in respect of the Harbour Area itself.

Bantry Bay is quite unusual amongst large Irish bays and loughs in that a substantial level of large maritime traffic, other than fishery and aquaculture vessels, has travelled the bay since the late 1960's. This traffic traverses the entirety of Bantry Harbour Authority Area, using the main deepwater channel, more or less equidistant between the north and south shores, to reach large vessel anchorages and offloading areas in the inner bay, whilst aquaculture development, including the MHI Roancarrig site and the proposed Shot Head site is generally restricted to the inshore margins of the bay.

Table 29 summarises the maritime traffic entering and leaving the Bantry Bay Harbour Area over the last decade by vessel type (where information is available). For the full record of traffic between 2001 and 2010, supplied by Bantry Harbour Commissioners, see Appendix 8. See also Section 2.1.4. for brief geographical details of the Bantry Oil Terminal and Leahill Quarry.

Table 29.
EIS for a salmon farm site at Shot Head.
Social interactions.
Summary of Bantry Bay commercial marine traffic other than fisheries and aquaculture vessels since 2001.

Year					All vessels								Grand total number
					Total number	Dead-weight tonnes (DWT)	Net registered tonnes (NRT)	Gross tonnage (GT)					
2001					173								173
2002					128	1,487,100	467,548	921,112					128
	Tankers				Bulkers				Liners				
	Total number	Dead-weight tonnes (DWT)	Net registered tonnes (NRT)	Gross tonnage (GT)	Total number	Dead-weight tonnes (DWT)	Net registered tonnes (NRT)	Gross tonnage (GT)	Total number	Dead-weight tonnes (DWT)	Net registered tonnes (NRT)	Gross tonnage (GT)	
2003	21	438,942	110,270	266,557	69	1,395,968	202,413	430,414	0	0	0	0	90
2004	25	659,884	179,642	400,642	26	131,914	49,199	79,159	1	1,465	1,347	4,376	52
2005	19	1,125,644	322,153	643,932	16	283,501	149,445	305,338	7	12,500	36,109	99,006	42
2006	22	1,216,551	353,862	720,889	19	239,162	90,590	184,319	5	14,457	33,387	93,375	46
2007	35	1,766,478	562,130	1,017,087	22	67,086	25,043	45,463	1	3,570	8,274	22,496	58
2008	21	966,389	282,819	592,721	40	253,729	76,894	167,601	7	29,524	57,282	152,628	68
2009	21	1,122,976	347,641	683,552	6	23,967	8,755	16,344	5	22,565	39,866	103,579	32
2010	46	1,487,787	485,161	991,961	0	0	0	0	9	17,028	38,534	104,595	55

Shipping traffic comprises three vessel types, which are described in the following three subsections.

6.5.1. Tankers

Tankers traffic is associated with the delivery and collection of oil products, to and from the Bantry Bay Oil Terminal on Whiddy Island, which was originally built by Gulf Oil but has been owned and operated for the last number of years by Conoco Philips, who also own Ireland's only oil refinery at Whitegate, in east Cork.

The largest tankers visiting the Bantry Bay Terminal (BBT) tend to be those delivering oil products directly from the Arabian Gulf. Smaller tankers are used to transfer smaller cargos of oils and fuels between the Whiddy terminal and smaller terminals around Europe. The Whiddy terminal was originally designed and licensed to receive tankers of up to 320,000 summer dead weight tonnes (DWT), with maximum dimensions of 340m length and 23m draft. However no tankers of this size have entered Bantry Bay, at least in the last decade and visits by the largest tankers that have supplied the terminal during this period have made up a fairly small numerical proportion of the total traffic. Of a total number of tankers of about 300 entering the harbour in the decade between 2001 and 2010, those of greater than 140,000DWT have been the following:-

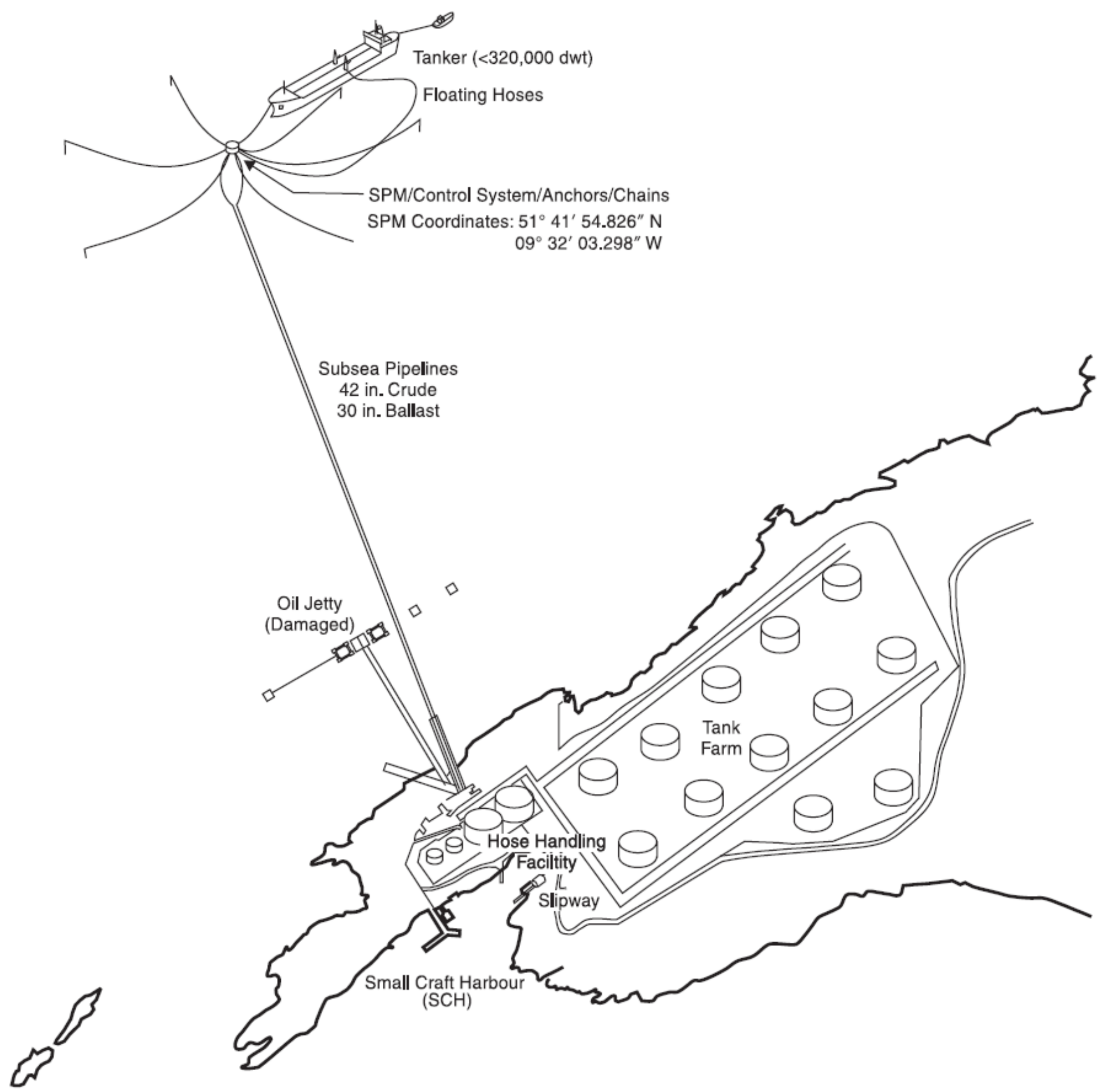
October 2001; MV Erviken; 154,146DWT; 274m, x 48m x 9m.
May 2002; MV Geres (Knock Sheen) 152,485DWT; 269m x 48m x 9m.
May 2002; MV Wlana 149,706DWT.
August 2005; MV European Spirit; 151,849DWT; 269m x 45m x 10.8m.
September 2005; MV Gerd Knutsen; 146,273DWT, 277m x 44m x 14.5m.
April 2007; MV Gerd Knutsen; 146,273DWT; 277m x 44m x 14.5m.
June 2007; MV Asian Spirit; 139,999DWT; 200m x 32m x 8.8m.
December 2008; MV Navion Europa; 265m x 42m x 9.5m.

The majority of the tankers entering the Bantry Harbour Authority Area are under 100,000DWT and mainly in the range of 20,000 to 50,000DWT, with dimensions in the range of 160m x 26m x 8m and 185m x 32m x 12m. Photographs of two of the largest tankers to visit Bantry Bay in recent years are shown in Figure 105.

Figure 105.
EIS for a salmon farm site at Shot Head.
Social interactions.
The oil tankers MV Gerd Knutsen and MV Erviken; two of the largest tankers to enter the Bantry Harbour Authority area.

Since the main Whiddy jetty was destroyed in the explosion of the MV Betelgeuse on 8th January 1979 (see Section 2.1.4), all tankers have been offloaded and loaded at the single point mooring, shown in Figure 106[90], which is situated approximately 1.55km offshore from the terminal. The width of Bantry Bay at his point, between Whiddy Island and the north shore, is approximately 3.74km.

Figure 106.
EIS for a salmon farm site at Shot Head.
Social interactions.
Location of single point mooring (SPM) at the Whiddy Terminal.



[90] Source ©Shipping Guides Ltd., Reigate, UK.

Tanker movements within the Harbour Authority Area are subject to the local byelaws and also to the standards set out in Conoco Philips' own Port Information Book for Bantry Bay. This designates the position of the Tanker Pilot Station, at which a pilot nominated by Conoco Philips must be taken aboard, at 51º36'N, 09 º47'W (ING 76486E 40048N). This is within the main channel area, roughly equidistant between St Lawrence's Point, at the eastern end of Bear Island and the southern shore, about 11.1km WSW of the SW corner of the proposed Shot Head site seabed area (see for example Figure 4), which is the nearest marked site location to the designated Tanker Pilot Station.

The information book also designates an anchorage area, weather permitting, where it has been determined that there is good holding ground, to be used in the event that a berth is not available for offloading at the terminal, on the arrival of the tanker. This is 1 to 1.5nm (1.85 to 2.78km) south of Shot Head. This area is approximately 1.59 to 2.52km (0.86 to 1.36nm) southerly from the SW corner of the proposed Shot Head site seabed area, which is the nearest marked site location to the anchorage area. The distance between the SW corner of the proposed Shot Head site and the southern shore at this point is approximately 4.54km (2.45nm)[91].

On the basis of the dimensions and coordinates supplied, an opinion was sought on the likelihood of conflicts arising between the passage and anchoring of tankers in Bantry Bay and the presence of the proposed Shot Head site. The following expert opinion was offered by Maritime Management[92], an Irish company offering management, consultancy and surveying services to the international maritime industry:-

"The presence of the Shot Head site will be a restriction in the area but, bearing in mind the width of the bay at this point, the distance between the site and the main deepwater channel and the designated position of the holding anchorage for tankers, the restriction is not regarded as significant enough to represent a hazard. Vessels should have no difficulty in keeping clear, <u>in normal circumstances</u>.

91 Note that the corner locations of the proposed site seabed area are used only to describe a seabed rectangle within which all the moorings for the fish farm installation must be anchored. The surface structures of the farm operation will always be considerably inshore from the site limits of the seabed area (see Figure 4) because of the required lengths of the moorings. The water depth throughout the site area is much as for the maim deepwater channel.

92 Maritime Management, The Watson and Johnson Centre, Church Road, Greystones, County Wicklow, Ireland. +353 1 2557440. www.bmml.ie.

However the proviso is added that, in an unprecedented circumstance, possibly arising from a combination of weather and irretrievable loss of power, with no external assistance available[93], if a vessel is driven into the immediate area of the proposed site, the primary danger to the vessel is likely arise from the shoreline bathymetry and topography between Shot Head and Mehal Head rather than from the presence of a fish farm."

6.5.2. Bulk Carriers

Bulk carriers have been used for the collection of stone products from the deep water jetty at Ireland's largest quarry at Leahill, 2.5km east of the Shot Head site, since 1968. At the peak of the quarry operations, bulker traffic exceeded tanker traffic by number of vessels per annum entering the bay. The Leahill quarry is now closed and seeking a buyer. However it has plenty of reserves and may or may not reopen as a quarry in due course. The biggest bulk carrier ever to load at Leahill was the Yeoman Bontrup, which last entered the bay in 2006. It is shown in Figure 107. This vessel is 96,772DWT, with dimensions of 250m x 38m x 8.6m. The majority of bulkers serving Leahill were in the range of 3,000 to 20,000DWT, with dimensions varying between 90m x 14m x 4m and 160m x 23m x 8.6m. There has been no bulker traffic to the Leahill Quarry since May 2009. Full details for bulker traffic as provided by the Bantry Harbour Authority are given in Appendix 8.

It is understood that the company Bantry Bay Pilotage offered pilot serves to bulk carriers serving the Leahill Quarry. This company was a respondent in the scoping study for the Shot Head proposal, as was Tarmac Ltd; see Appendix 1 and the extracts from their responses given above. The following expert opinion has been offered by Maritime Management on the views expressed by Bantry Bay Pilotage and Tarmac:-

"In respect of the anchorage of large tankers and bulk carriers in or close by the proposed Shot Head site area, we would not expect masters of large vessels to be happy that close to the northern shore. There is some shelter offered by the low cliffs to smaller ships in NW to NE winds (not the prevailing condition, which is westerly). However, there is similar shelter for such vessels in Trafrask Bay and to the east of Mehal Head. We would assume that ships arriving and departing Leahill Quarry would traverse via the holding anchorage designated by

[93] Note that the BBT Information Book states that It is a directive of the Port Authority that vessels proceeding to the SPM will proceed at a safe speed and be escorted by tugs as directed by the Pilot.

BBT or close thereto, 10 to 15 cables to the south of Shot Head. The positioning of the farm means that vessels need to stand off at least 4 cables[94] from Shot Head (considerably closer than the holding station) but there is ample room in the bay at this point.

Our proviso in respect of unprecedented circumstances applies."

6.5.3. Passenger liners

Passenger liners travel up Bantry Bay to anchor in both Glengarriff Harbour and Inner Bantry Harbour. The biggest passenger liner to enter the Bantry Harbour Authority Area was the Marco Polo, which is 6,472DWT, with dimensions of 176m x 24m x 8.2m; see Figure 107. Most visiting passenger liners are in the range of 1,000 to 5,000DWT with dimensions between 105m x 18m x 4.7m and 205m x 26m x 8.6m. Between zero and nine passenger liners have visited Bantry Bay per season in the last decade. It would normally be expected that these vessels would pass well clear of the proposed Shot Head site down the main deepwater channel, en route to and from their final anchorages in the inner bay. However there may be circumstances when the need to employ a holding anchorage would arise. In these circumstances the comments and observations made above would apply.

On the basis of the information gathered and the expert opinion provided, it is submitted that the proposed site would not represent a material obstruction to shipping and navigation in the bay. Further, whilst an unprecedented circumstance cannot be ruled out (the explosion of the MV Betelgeuse in January 1979 would be defined as an unprecedented circumstance) it is not a sufficient risk to disqualify the granting of an Aquaculture Licence for the proposed Shot Head site.

It should be further noted that it would be a condition of any licence granted that the limits of the proposed site area and the structures therein would be marked for navigation as deemed appropriate by the regulatory authorities, including the Marine Survey Office and the Commissioner for Irish Lights. As for all aquaculture installations, the site would also be marked on the next edition of the relevant Admiralty Chart/s.

Further contact has already been established both with the operators of the Bantry Bay Terminal, and the Bantry Harbour Office, with whom it has been agreed to establish navigation procedures for aquaculture vessels in the area should a licence for the proposed Shot Head site be granted.

[94] One cable = 0.1 nautical miles (nm) = 185.2m or 0.1852km. Thus 4 cables = approximately 750m.

Figure 107.
EIS for a salmon farm site at Shot Head.
Social interactions.
The bulker MV Yeoman Bontrup and the passenger liner Marco Polo; the two largest vessels of their type to enter the Bantry Harbour Authority area.

6.6. Tourism.

See Section 2.1.2. The potential for tourism is far from realised as a contributor to the economy of SW Ireland and it is widely regarded as a major growth area. Bearing in mind its potential to the area, every effort should be made to ensure sustainable tourism development. However, the seasonality and vagaries of tourist numbers to the western peninsulae are well known. A fragile economy as far removed from commercial centres as this would be better served by a number of significant sources of income and employment rather than depending too greatly on a single, seasonal one. Aquaculture is regarded as a good candidate for such an approach because it fits well with existing local fisheries interests, skills and services.

It is also submitted that the overriding majority of visitors to the south-western peninsulae are not from low population rural or coastal areas, similar to those that they are visiting, but from inland, urban areas. Under these circumstances, any carefully considered, well-planned and well-integrated development is a source of interest and focus to tourists, as part of the tradition and living landscape of the area.

It is submitted that the Shot Head site as proposed will have no deleterious impact on the development of tourism in the area.

6.7 Antiquities and cultural heritage.

The peninsulae of the south west of Ireland are rich in antiquities. Stone circles, ring forts, standing stones, burial sites, all dating from prehistoric times and monastic remains, other early Christian artefacts and burial grounds are much in evidence. There are a number of Martello Towers and other lookout posts and fortifications from the Cromwellian era still standing, in particular to the seaward end of Bantry Bay.

However, there are no submerged antiquities in the immediate Shot Head site area, as far as is known. Presumably it is for this reason that the Department of the Environment, Heritage and Local Government did not respond to the scoping study (see Appendix I) to request an appropriate assessment in the form of an underwater archaeological survey as part of this EIS, as is normally the case, where such artefacts exist.

The proposed operation is not regarded as a threat to any cultural artefact.

6.8 Discussion.

The location, size, orientation and marking of the Shot Head site has been carefully considered in the context of other users. No known navigational channels will be obstructed by the site. Whilst occupying a large notional seabed area, the surface structures proposed for the site are small relative to Bantry Bay overall. The site is also well clear of the main channel down the bay, yet sufficiently offshore to allow inshore fishing vessel to pass on its landward side. This all allows for more than adequate clear sea area for navigation under sail or power to any pier or harbour in the vicinity of the site. The site will be marked with radar reflectors, winkie lights and navigational buoys as per statutory requirements, set down by the Commissioners for Irish Lights.

On numerous occasions, salmon farm structures have been used to provide shelter or safe haven for vessels in poor weather and salmon farm vessels and staff have been involved in a number of rescue missions to vessels in difficulty.

Whilst vessels serving the proposed Shot Head site (including well boats) could be considered to constitute substantial marine traffic in the immediate site area, no impact on other navigation is expected to arise as a result of proposed installation, if it is granted a licence.

Section 7.
Mitigating measures.

Measures to mitigate the impacts arising from the presence of the proposed site are covered elsewhere in this document, particularly in Sections 3 to 6. Impact minimisation is central to the proposed production plan in the interests of fish welfare and operational and commercial efficiency. The following mitigating measures have been and will be undertaken.

7.1. Site choice.

Selected and sized to minimise hindrance to all other water users and to minimise visual impact and risk of fish escapes due to exposure to storm conditions. The location and size of the proposed Shot Head operation are considered such that current flows in the area, especially the westerly residual current are regarded as being more than adequate for the sustainable dispersal and dilution of wastes.

7.2. Land based facilities.

The shore-based facilities of Marine Harvest's Bantry Bay operations comprise an office at The Pier, Castletownbere and the company Operations Yard on Dinish Island, within the Harbour Centre. These facilities are clustered with the majority of other fisheries infrastructure in Castletownbere. Feed is currently delivered on a just-in-time basis for delivery by sea direct to Roancarrig. There will be no physical extension of the existing facilities if the proposed Shot Head operation is licensed and established. The current operational strategy will simply be extended to cover the proposed Shot Head site. The company’s land-based facilities and the activities around them thus have minimal visual impact and create no hindrance to other activities in the area.

7.3. Cage arrays.

Orientated and sized, following DCMNR guidelines, to reduce visual impact and avoid obstruction to other water users. Deployment of navigational markers to alert marine traffic to presence of cages.

7.4. Cage equipment specifications.

Colours of surface structures designed to minimise visual impact; built to specifications to fully withstand local climatic and hydrographic conditions in order to reduce risk structural failure or fish escapes.

7.5. Mooring systems.

Designed to minimise visual impact (mainly submerged).

7.6. Vessels.

Vessels of standard fisheries design in standard livery, to merge with existing fisheries activities; moored clear of public piers when not in use to minimise hindrance to other pier and water users.

7.7. Tidiness.

Tidiness of land base, piers, and offshore structures to be maintained, to reduce visual impact and maintain hygiene.

7.8. Single generation site operation and fallowing.

Biennial, single generation cycle with a minimum two month biennial fallowing period. Synchronous whole-bay stocking, treatment, harvesting, fallowing and rotation an option, subject to agreement with the other salmon farm operator in the bay; to avoid infection spread and reduce sea lice infestation pressure on subsequent generations; to mitigate organic loading and allow for site recovery between periods of occupation.

7.9. Operation under certified organic principles.

Use of certified organic feed, low stocking densities and minimal use of medication, to mitigate impacts on the environment and improve fish welfare

7.10. Cage volume / stocking density.

Selected under the ruling organic standards to improve welfare, health, quality, growth efficiency and feed conversion rate of stock; to reduce organic loading per unit benthic area.

7.11. Veterinary support.

Regular veterinary inspections and proactive health management plan to mitigate potential fish health and welfare problems (Fish Health Plan, Volume 2, Appendix 3.1).

7.12. Vaccination.

To reduce antibiotic usage and maintain fish health and welfare.

7.13. Live-haul harvesting, fish movements and grading.

To reduce use of local piers and rural, tourist orientated routes; to improve fish welfare and harvest quality and reduce stress and mortality to fish.

7.14. Improvement in ration quality (organic standard).

To maintain fish nutrition, feed conversion rate, fish health and growth at state of the art level; to reduce organic loading per unit of production. To eliminate the use of non-sustainable marine origin feed ingredients.

7.15. Lice treatment techniques.

Use of latest methods, including the use of well boats for bath treatments; to optimise treatment efficacy, improve fish welfare and minimise lice loadings, infestation pressure, fish stress and mortality. To reduce residue levels and potential for effects on non-target species. Treatment rotation to reduce the risk of development of treatment resistant lice strains and to maintain the efficacy of treatment.

7.16. Avoidance of use of net antifoulants.

(A requirement of organic standards). To mitigate against the effects of copper and zinc in net antifoulant formulations.

7.17 Proactive adoption of current best practice.

To mitigate against the impacts of outdated methodologies.

7.18 Achievement of safety standard awards.

To mitigate against accidents and their consequences.

7.19. Achievement of quality standards.

To maintain quality.

7.20. Achievement of hygiene standards.

To mitigate against poor hygiene.

7.21. Achievement of environmental standards.

To mitigate against environmental impact.

7.22. Implementation of wide-ranging standard operating procedures.

To standardise all operational activities; to train staff and mitigate against operational failures.

7.23. Emergency plans; standard operating procedures for emergencies.

To reduce occurrence and impacts of emergency events such as mass mortality and fish escape (see Section 8).

Section 8.
Emergency plans.

Emergency plans apply to eventualities, which, as a result of circumstance or unforeseen occurrence, may fall temporarily out of the control of the operator. It must be emphasised at the outset that such eventualities are extremely rare; none of those listed has occurred on MHI sites to date and are not known to have occurred on any other local aquaculture installation in the last six years. That said, that such hazards exist cannot be ignored. In many cases it is their infrequency and lack of familiarity, which are the primary causes of loss of control. Consequently, adequate emergency plans must be in place to deal with such eventualities. Insofar as is possible, risk of hazard or consequential event is mitigated or reduced by:-

- Site selection.
- Use of adequately specified equipment and structures.
- Installation of appropriate management systems.
- Standard registration of all farm operational data.
- Employment of staff suitably qualified for job specified.
- Diver qualification to a minimum of HSE Part 4 diver’s certificate; all divers to be accompanied underwater.
- Regular equipment inspection.
- Regular servicing of vessels, vehicles and other moving plant.
- Regular inspection of safety aids (life rafts, fire extinguishers, life jackets, navigation lights, winkies).
- Regular inspection and testing of diving equipment.
- Provision of guards over moving plant.
- Marine safety and rescue training.
- Wearing of lifejackets for all staff at sea
- First aid training and availability of first aid kits.
- Availability of emergency flare kits.
- Fitting of life rafts to all main vessels
- Disciplinary procedures.
- Ready availability of radios, telephones and emergency numbers lists.
- Protective clothing where necessary.
- Prohibition of unaccompanied access to company equipment and vessels by contractors, representatives, public servants and private individuals, who must be also provided with waterproofs and safety equipment as necessary when on company property.

Much of this information is enshrined, as required, in the Company's Stranded Operating Procedures (see Appendices 2-4), which set out the lines of responsibility for overseeing all operational health and safety systems and procedures.

In salmonid farming, the list of potential hazards, or circumstances which may lead to consequential hazardous events or loss can be summarised as follows:-

- Staff
  Injury, man overboard, illness at work, poisoning, fire.

- Vehicles
  Breakdown, collision, fire

- Vessels
  Loss of power, capsize, collision, grounding, fouling, loss of radio contact, fire.

- Fish farm installations:-

  - Fish mass mortality
    May result from asphyxiation, disease, predator attack, poisonous blooms, oil leakage or other contamination; see SOP 25560 [001], Appendix 4.3.

  - Mass fish escape
    May result from loss of net integrity (predator attach), wear and tear, storm damage, of collision

  - Normal weather eventualities
    Collision with vessel, loss of net integrity, fish escape, net fouling, poisonous blooms, predator attack, contamination or oil leakage.

  - Storm weather eventualities
    Structural or net damage, loss of moorings, fish escape, cage adrift.

8.1. Staff.

All staff are instructed to wear life jackets or floatation suits at all times when at sea. All vessels will carry first aid kits, radios or mobile telephones and flare kits. Staff will undergo routine training in first aid and rescue, including BIM courses in marine safety, first aid and radio use.

In the event of an emergency, the attending personnel must contact the relevant base station, stating the nature of the event, position and other relevant details. The base station will then contact any required emergency service. In the case of staff at sea, nearby vessels must also be contacted, as required.

In the event of accident at work, a report must be submitted to the local Health and Safety Authority Office.

8.2. Vehicles.

Any event involving vehicles, which is hazardous or may lead to a hazard, is dealt with in much the same way. Radio or telephone contact to the relevant base station must be used to raise in-house support or emergency services as required.

8.3. Vessels.

Vessels carry first aid kits, radios or mobile telephones and flare kits. Larger inboard vessels must carry radios, fire extinguishers, asbestos blankets and life rafts / lifebelts. Any injury arising must be dealt with using standard first aid procedures, involving contact to shore base, and onward to emergency service as required. In the event of vessel damage, capsize or loss of power, contact is made to the base station with position and nature of event, with a request for assistance. Further actions are taken as necessary to ensure staff and public safety and minimise the risk of loss of vessel or consequential loss. In the case of events involving vessels, depending on the seriousness of the incident, a report must also be submitted to the Department of Transport, Marine Safety Directorate, Marine Suirvey Office. See also SOP 28076 [001], Appendix 4.4 and SOP 28074 [001], Appendix 4.5.

8.4. Fish farm installations.

Barring serious human accidents on or around farm installations, the main, albeit rare, hazards associated with salmon farm units are:-

- Mass fish mortality may occur as a result of collision / net collapse, disease, asphyxiation, storm damage, poisonous phytoplankton, predator attack, oil leakage and other contamination; see SOP 25561 [001], Appendix 4.2.

- Mass fish escape, which may follow as a loss of net integrity in storm or even normal weather conditions, or follow other structural damage to the cage structures (for example by collision). See SOP 25560 [001], Appendix 4.3.

These are considered the main hazards because they carry the greatest risk of widespread consequences. Other possible hazards are those involving collision between moving vessels and cage structures, loss of moorings and drifting of cages. Dealing with these eventualities separately:-

8.4.1. Mass fish mortality.

See SOP 25560 [001], Appendix 4.3. More often than not, mass mortality is avoidable. Such events have greatly reduced in number with the maturation and increased experience base of the industry. The most predictable causes are associated with disease and asphyxiation. The former can often be brought on by stress, associated with high stocking density, fouled nets and warm weather, also the primary cause of asphyxiation. In the case of the Shot Head site, the most potent strategies for the avoidance of a mass mortality are low stocking densities required for organic farming, the experience of the staff and the full adoption of single bay management.

Appropriate site selection, regular net inspection, anti-fouling and cleaning will also all assist in avoiding these problems. Vaccination, regular veterinary inspection and appropriate action on the first signs of stock distress can greatly reduce the risks of disease outbreak.

Whatever the cause, the primary risks in a fish mortality event are disease transmission to other cages (in a disease-based event) and pollution. Once the mortality has been registered, the company plan comprises the use of all hands, divers and boat-mounted, crane-operated brailers and fish pumps to remove the mortalities, with counting, into harvest bins as quickly as possible. Standing arrangements exist with renderers for the disposal of mass mortalities in such an emergency. Following mortality removal, diver must check the fish remaining in the cage on ensuing days to remove any additional mortalities. Once the event has passed, the fish remaining in the cage must be moved and counted into new accommodation, in order to reconcile the total number of fish in the original cage and to confirm the size of the mortality. The quicker the mortalities and moribund fish are removed, the lower the chance of consequential pollution or disease hazard.

8.4.2. Fish escapes.

See SOP 25561 [001], Appendix 4.2. No farmed escapees have been reported in Bantry Bay since MHI acquired the Roancarrig site. The stock in the farm cages is the stock in trade of the company. As well as being fully aware of the potential impact risks of escapees on local wild fisheries (subject to species in question and season), it is essential to the company's commercial viability to contain its fish for harvest. Thus the guidelines set out below to avoid fish escapes are adhered to as a matter of commercial necessity as well as in the interests of the environment. In respect of fish farm escapes, MHI will follow the guidelines on containment of farmed salmonids, drawn up between the North Atlantic Salmon Organisation (NASCO) and the International Salmon Farmers Association (ISFA).

These guidelines first set out preventative measures, which are observed by the company, in respect of:-

- Site selection.
- Equipment and structural specification.
- Preventative strategies, inspection and maintenance.
- Staff training.

Under these guidelines, the Shot Head site has been selected with an eye to fish escape risk, which increases, for example, in areas exposed to excessively heavy seas or heavy boat traffic. All floating cage equipment, nets and associated structures will be specified to withstand local current and wave climate conditions (see Section 2.2). Mooring systems will be designed to withstand predicted 50-year local wave climate conditions and thus to protect the integrity of the cages. Preventative strategies include guidelines for the use of vessels around cages and the provision of adequate navigational lighting and radar reflectors to prevent damage arising due to navigational errors by non-company vessels.

Net Inspection (by diver and on net-changing; see Appendix 2.1; SOP 28941 [001] and SOP 26166 [001]) as well as maintenance of nets and other cage components (see Appendix 2.1; SOP 28646 [001] and Appendix 2.2; SOP 28940 [001]) are carried out on a routine basis. All nets are number-coded, the net stock is rotated and usage recorded. Nets are cleaned and dried prior to storage and are stored off the ground in vermin-free conditions. Nets are inspected before use and regularly renewed. Spare nets are always available. Members of staff are trained in preventative net inspection and maintenance.

All farm activities which may increase the risk of fish escape are carried out by staff aware of the risks and trained for the task in hand. The majority are also covered by Standard Operating Procedures, These include:-

- Fish sampling.
- Fish movements for smolt transfer, grading, relocation and harvesting.
- Net changing.
- Use of vessels in the vicinity of cages.

The practice of moving fish by cage towing is not now used under current best practice, the preference being to use well boats, in the interests of both fish health and safety.

In readiness for any escape event, the company has a contingency plan and a registration and verification procedure. Any indication of escape, such as loss of loss of net integrity, will be immediately followed up by repair or net change, as required, subject to weather conditions. Once an escape has been confirmed, the event must be reported to the Aquaculture and Foreshore Management Division of DAFF (AFMD) in Clonakilty and to the South Western office of Inland Fisheries Ireland (IFI). The fish remaining in the cage must be transferred and counted in to a new enclosure and the extent of the escape verified. The event is then fully reported, stating species, strain, hatchery of origin, age, mean weight and length of stock, escape number and likely percentage of maturation in the year of escape. This information must be despatched as soon as possible and preferably within 24 hours to the AFMD and IFI. The company will co-operate with any program attempting to recapture the stock, which may be mounted or ordered by the relevant authorities. See also SOP 25561 [001], Appendix 4.2.

A similar verification and reporting procedure must be also undertaken in the event of unexplainable reductions in stock numbers discovered, for example, during normal transfer, grading or harvesting procedures. Under these circumstances, the cage structures occupied by the stock in question must be fully inspected following discovery of the shortfall.

Section 9.
Difficulties encountered in preparing this document.

Apart for the issues associated with the depth and complexity of the requirements for the environmental impact assessment for marine salmon farm installations in Ireland, no problems were encountered with the completion of this EIS document.

Section 10.
Conclusions.

The salmon farming company Marine Harvest Ireland wishes to apply for an Aquaculture Licence and a Foreshore Licence to operate a salmon farm site at Shot Head, Bantry Bay, County Cork. It is expected that the site will be operated, in the first instance, on a single generation, biennial production cycle, alternating with the similar site operated by the company, at Roancarrig, Bantry Bay, County Cork. This Environmental Impact Statement arises from an Environmental Impact Assessment (EIA) of the likely consequences of operating the proposed farm.

A public scoping study was conducted prior to the commencement of the EIA for the proposal. This was circulated to a total of 65 parties and was forwarded to a further two parties. 15 (22.4%) responses were received from these addressees. Of the 15 responses received, the following were the primary issues raised; 5 (33.3%) were acknowledgments of receipt with no comment, 1 (6.7%) was in favour for the reason of employment to be created, 2 (16.7%) had concerns about fishing grounds in the site area, 1 (6.7%) was concerned with environmental and compliance issues and 6 (40.0%) dwelt on navigational and access issues, primarily associated with the marine traffic in Bantry Bay, comprising oil tankers, bulk carriers and passenger liners.

These issues have all been addressed and answered in the EIA / EIS process.

The following are the mian findings of the EIA for the proposal, as reported in this EIS:-

- The choice of candidate sites for large a scale salmon farm in Bantry Bay is limited by the shallowness and exposure of other inshore areas in the outer bay and the uptake of sites for other uses, primarily shellfish farming in the inner bay. Nonetheless a standard and rigorous set of site selection criteria have been applied, which take full account of other users of local resources and the marine and terrestrial environment in the locality. It has been concluded that the location selected at Shot Head creates no consequential spatial interference with other bay activities.

- Agriculture, tourism and the fisheries are the primary economic drivers in the area. Finfish and shellfish aquaculture has played an increasingly important role in the fisheries sector over the last 25 years or so, both through direct employment and through new jobs created in the local fisheries-based support infrastructure.

- The meteorology of West Cork is influenced by the Gulfstream, bringing with it relatively mild water and air temperatures. Prevailing winds are south-westerly, and blow at over 5.5msec^{-1} for over 50% of the year. Rainfall is approximately 1200mm pa at sea level and 2,000mm pa over 150m above sea level.

- A hydrography study conducted as part of this assessment shows that currents in Bantry Bay are a result of diurnal tidal forces, influenced by wind about 50% of the time, in particular in winter. The axis of the bay runs roughly in the prevailing wind direction. Mean still- weather currents in the proposed site are approximately 6cmsec^{-1} in midwater and 5cmsec^{-1} near the seabed. Mean depth in the site area is 36.5m. Mean current data suggests that the site can be classified as a Level 2 site, suitable for farmed salmon production in excess of 1,000 tonnes per annum.

- A wave climate analysis of the site area indicates that wave climate is influenced by either Atlantic storm conditions or local storm conditions, or both, operating simultaneously. Overall, the model predicts that the wave climate at Shot Head will be of medium to high intensity, increasing with increasing storm return period. However there would be few days in the year when access to the site or work on site would be unduly affected. This is primarily due to the dissipation of the force of Atlantic swell waves as they make their way up Bantry Bay, into the relatively shallower waters its margins and, in the case of local storm wind waves, due to the relative shortness of local fetches. Maximum significant wave height at the proposed site centre in a 1-in-50-year return period storm is expected to be about 5m (from trough to peak), whilst the worst average annual storm will have a significant wave height of about 3m. Such a wave climate is deemed acceptable for the proposed operation.

- A 20-year historical database of water column biotic and abiotic parameters for Bantry Bay lie within the normal range for European inshore coastal waters.

- Based on the findings of the hydrographic study, the still-weather flushing time for Bantry Bay area is estimated at 8.3 to 17.8 days, for mean spring to mean neap tide. This results the tidal flushing of the bay with very considerable quantities of Atlantic water (mean still-weather tidal flushing of the bay is estimated at 2.7 x10^{10}m^{3} per month). As a result of this very large water volume, the biggest single influence on water column conditions in the bay is the tidal flushing

- A benthic survey was also executed as part of this commission. The seabed in the proposed Shot Head site area is composed of sand with a varying admixture of gavel and silt. The only exception to this lies in the most exposed area of the site, to its southern side, where coarse gravels were the main constituent in the seabed. There was a single, rocky patch, outcropping close to the centre of the site. Redox potential in the sediments was found to be positive within its measurable depth of some 7 to 8cm, indicating clean well-oxygenated, healthy substrate conditions. Redox was negative only very rarely, associated with the finest samples collected, for example from the control station, 500m to the SW of the proposed site area. As expected, the organic carbon levels in the collected sediments samples gave no indication of the presence of exogenous carbon in the site area.

- All in-site stations sampled were well populated with benthic infauna, with 300-500 specimens recorded in all samples. A slightly lower count at the control site was felt to be due to the finer sediments. Almost without exception, the samples were dominated by brittle stars. The only exception was the station to the south of the site area, with the coarsest sediments. This had a rather different species profile, with several species unique to it, as might be expected. Univariate analysis of the benthic raw data indicate no undue stress, such as organic loading in the site area. Infaunal trophic indices (ITI) were high, suggesting a natural community profile, unchanged by stressors. Multivariate analysis highlighted the stark differences in the community profile at the southernmost site relative to all other sample stations, arising from its exposure and coarser sediment conditions.

- The only species of economic importance found in any number in the site area was the Dublin Bay prawn, *Nephrops norwegicus*. However the number of burrow complexes found indicated that the species was unlikely to be present in exploitable quantities. It is understood that shrimp (*Palaemon serratus, Crangon crangon*) are potted for in the site area but only one example was seen in extensive ROV surveys. No scallop (*Pectinidae*) were seen and there was no evidence of trawl tracks (for example for *Nephrops*) on the seabed.

- The deployment of twelve 128m circumference, circular plastic ring cages is proposed for the Shot Head site. It is proposed to increase this to a to a temporary maximum of fourteen cages, to assist with the separation of stock approaching and during the harvesting period, at the end of each 2-year production cycle. Side wall depth of the cage nets will be 15m, with a nominal net centre depth of 15m.

- The seabed area to be applied for is 850m x 500m or 42.5ha, with the long axis running 257º / 77º to grid north. This overall site size is requested in order to fully accommodate the lengths of the moorings for anchoring the cage grid, to accommodate both the cages and a feed barge and to allow sufficient room for the relocation of the cage installation over new ground, within the site area, for improved fallowing, should the need arise. Visible cage structures will cover only 1.56ha (3.25%) of the site area. The maximum seabed area occupied, to the limits of the mooring anchors will be 19.20ha, or 45% of the site area to be applied for.

- The maximum proposed input to the proposed site, for the 2-year production cycle will be 850,000 smolt. Maximum projected standing biomass will be 2,800 tonnes. This would be reached, with full production, in 2012 earliest, from which point, 3,500 tonnes of farmed salmon, of nominal mean weight 4.5 to 5.6kg will be harvested from each smolt input, in each two- year cycle.

- Wastes discharged from the proposed Shot Head site at full production (first smolt input October 2010 at the earliest), will comprise some 1,100 tonnes of Biological Oxidation Demand (BOD), required mainly for the oxidation and assimilation of 775 tonnes of organic solids, 155 tonnes of nitrogen and 22 tonnes of phosphorus (both mainly soluble), discharged per two-year production cycle. These figures are as expected for the biennial production of 3,500 tonnes of salmon and constitute only a minor input into the bay relative to other inputs.

- The meteorology, bathymetry and hydrography of Bantry Bay are regarded as suitable for the proposed development. Wind, current and wave climate together endow local waters with sufficient dispersive power to dilute and assimilate projected inputs from Shot Head and other existing and proposed aquaculture operations, along with those from other aquaculture, as well was all agricultural and human wastes (these latter making up by far the majority of the wastes input into the bay), with a very considerable margin of safety. Thus the assimilation of all existing and currently projected wastes is well within the carrying capacity of the bay. As a result no measurable or lasting impact is expected to arise from the wastes discharged from the Shot Head site. This was tested by the development of a model using a "worst case" scenario where all salmon farm sites in the bay operated synchronously rather an alternately. The resulting calculated nutrient contributions made little difference to the ambient concentrations of nutrients in the bay, which remained well within approved Environmental Quality Standard (EQS) levels.

- The recent sea lice record of the MHI Roancarrig site, west of the proposed Shot Head site and downstream of all salmon rivers in the bay, shows that numbers of ovigerous female lice have been maintained below the trigger levels set by the regulator using MHI's rotating treatment program. However, the record indicates infestation of the farmed fish, presumably by drifting wild copepodids in spring 2010. These were treated to reduce the population before they matured on the farmed stock, thus avoiding reinfestation.

- The geographical and hydrographical location of the proposed Shot Head site, relative to river estuaries and other salmon farm sites in the bay, coupled with a vigilant monitoring, and synchronous treatment and fallowing procedures are expected to limit the opportunities for sea lice reinfestations of both native wild salmonids and farmed salmon in the locality.

- Whilst noting the importance of wild salmonids to conservation objectives and angling revenues in the locality, it is submitted that the bulk of the decline in wild stocks throughout Ireland (and Scotland) occurred before the introduction of salmon farming and seems more related to historical over-exploitation by the now banned commercial fishery than to any other factor. The proposed salmon farming operation is not expected to pose an impact risk to local wild salmonids.

- The economics of the local inshore capture fishery is now dominated in both tonnage and value terms by rope grown mussel returns by vessels of under 10m. This is, strictly speaking, an aquaculture resource rather than an inshore fishery resource. No historical database prior to 2006 was available for analysis but it is assumed that there has been a downward trend in inshore fishery catches landed to Bantry Bay ports, as elsewhere throughout the North Sea area. It is nonetheless notable that the inshore fishery landings to ports within Bantry Bay remains a valuable resource, with total annual landings worth €2.5M to 5Mpa (2006-2010 data). This is made up for the most part of modest quantities of valuable shellfish species such as lobsters and shrimp, as well as large quantities of lower value species, in particular as edible crab and rope mussels. It would appear that inshore trawling accounts for little revenue to Bantry Bay ports.

- Bantry Bay is quite unusual amongst large Irish bays and loughs in that a substantial level of large maritime traffic, other than fishery and aquaculture vessels, has travelled the bay since the late 1960's. The traffic comprises oil tankers accessing the Whiddy Island Oil Terminal, bulk carriers loading at the Leahill Quarry, 2.5km east of the proposed Shot Head site (the quarry is now closed but there is a possibility that it may reopen at some future date) and passenger liners. Peak traffic has reached over 170 vessels in some years past but is now generally no more than half of this. This study concludes that this traffic would not be impeded or endangered by the operation of a salmon farm site at Shot Head but it would be wise for procedures for the navigation of salmon farm vessels to be established with these stakeholders.

- Bantry Bay is an area of outstanding scenic beauty, where visual intrusion is a sensitive issue. The position of the proposed Shot Head site has been selected with this in mind. To all intents and purposes, the Shot Head site will only be very visible as a "foreground object" from a single, rarely frequented coastal vantage point. This view is shared by a single property in the hamlet of Roosk, which lies to the east and above the site near Mehal Head. Other than this, site structures will only be visible in long-range to very long range views, intermittently, at distances of 5km or more. It is submitted that, of all the salmon and shellfish farm sites in Bantry Bay, the proposed Shot Head site would be the least obtrusive on local views.

- The environmental management plan and mitigating measures proposed within this EIS document will enable the proposed salmon farm to operate with no material or consequential negative impact on Bantry Bay.

- On the basis of the findings of this study it is recommended the Shot Head site selected and the production plan proposed be granted an Aquaculture Licence and Foreshore Licence.