Shellfish Stocks and Fisheries Review 2018






BIM Ireland's Seafood Development Agency

Marine Institute
Foras na Mara

Shellfish Stocks and Fisheries

Review 2018

An assessment of selected stocks

The Marine Institute and Bord Iascaigh Mhara

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1 Introduction

This review presents information on the status of selected shellfish stocks in Ireland. In addition, data on the fleet and landings of shellfish species (excluding *Nephrops* and mussels) are presented. The intention of this annual review is to present stock assessment and management advice for shellfisheries that may be subject to new management proposals or where scientific advice is required in relation to assessing the environmental impact of shellfisheries especially in areas designated under European Directives. The review reflects the recent work of the Marine Institute (MI) in the biological assessment of shellfish fisheries and their interaction with the environment. Stock status and exploitation status indicators are presented, where estimated, as a contribution to the assessment of Good Environmental Status (GES) of shellfish for Descriptor 3 (Commercial Fisheries) of the Marine Strategy Framework Directive (MSFD). Mitigation measures to protect habitats within Natura 2000 sites, which have been developed in response to Habitats Directive Article 6 assessments and in consultation with the industry, are summarised. The competent authority for the management of these sites is the National Parks and Wildlife Service (NPWS). The Department of Housing, Planning and Local Government oversees the implementation of the MSFD in Ireland.

The information and advice presented here for shellfish is complementary to that presented in the MI Stock Book on demersal and pelagic fisheries. Separate treatment of shellfish is warranted as their biology and distribution, the assessment methods that can be applied to them and the system under which they are managed, all differ substantially to demersal and pelagic stocks.

Shellfish stocks are not generally assessed by The International Council for the Exploration of the Sea (ICES) and although they come under the competency of the Common Fisheries Policy they are generally not regulated by TAC and in the main, and other than crab and scallop, are distributed inside the national 12nm fisheries limit. Management of these fisheries, by the Department of Agriculture, Food and Marine (DAFM) is based mainly on minimum landing sizes but increasingly also by the use of input or output controls.

A co-operative management framework introduced by the Governing Department and BIM in 2005 (Anon 2005) and under which a number of fishery management plans were developed was, in 2014, replaced by the National and Regional Inshore Fisheries Forums (RIFFs). These bodies are consultative forums, the members of which are representative of the inshore fisheries sector and other stakeholder groups. The National forum (NIFF) provides a structure with which each of the regional forums can interact with each other and with the Marine Agencies, DAFM and the Minister.

Management of oyster fisheries is the responsibility of The Department of Communications, Climate Action and Environment (DCCAE) implemented through Inland Fisheries Ireland (IFI). In many cases, however, management responsibility for oysters is devolved through Fishery Orders or 10 year Aquaculture licences to local co-operatives.

The main customers for this review are DAFM the RIFFs, NIFF and other Departments and Authorities listed above.

2 Shellfish Fleet

2.1 Fleet capacity

The total registered capacity of the Irish fishing fleet, as of December 2018, was 62,835 gross tonnes (GTs) and 2,004 vessels. The polyvalent general segment was the largest and included 31,270 GTs and 1,384 vessels. The polyvalent potting segment had 337 registered vessels and 716 GTs while the bivalve (specific) segment had 2,298 GTs and 153 vessels.

2.2 Fleet structure

The Irish fleet is, currently divided into 5 segments. Of these five segments (Aquaculture, Specific, Polyvalent, Beam Trawl and RSW Pelagic) two are broken into sub-segments, namely the Polyvalent and Specific Segments. Aquaculture vessels do not have fishing entitlements. Beam trawl vessels fish mixed demersal fish using beam trawls and RSW Pelagic are large pelagic vessels with refrigerated seawater tanks and target pelagic species. The **Polyvalent Segment** is divided into the following four Sub-segments;

(1) Polyvalent [Potting] Sub-segment; vessels of <12 m length overall (LOA) fishing exclusively by means of pots. Such vessels are also <20 GT. Target species are crustaceans and whelk.
(2) Polyvalent [Scallop] Sub-segment; vessels ≥10 m LOA with the required scallop (*Pecten maximus*) fishing history. These vessels also retain fishing entitlements for other species excluding those listed in Determination No. 21/2013.
(3) Polyvalent [<18 m LOA] Sub-segment;
Vessels with fishing entitlements for a broad range of species other than those fisheries which are authorised or subject to secondary licencing as listed in Determination No. 21/2013 (http://agriculture.gov.ie/fisheries/).
(4) Polyvalent [≥18 m LOA] Sub-segment;
Vessels with fishing entitlements for a broad range of species other than those fisheries which are authorised or subject to secondary licencing as listed in Determination No. 21/2013.

The **Specific Segment**, which entitles vessels to fish for bivalves only, is divided into the following two Sub-segments;
(1) Specific [Scallop] Sub-segment for vessels ≥10 m LOA with the required scallop (*Pecten maximus*) fishing history
(2) Specific [General] Sub-segment for all other Specific vessels irrespective of LOA.

In December 2018 almost 75% of vessels in the fleet were under 10 m in length. These are typically open or half-decked traditional fishing vessels that fish seasonally in coastal waters. Ninety five percent of polyvalent potting vessels were less than 10 m in length and all were under 12 m. Approximately half of the specific fleet of 153 vessels were under 10 m.

2.3 Fleet capacity transfer rule

The following rules apply to the transfer of capacity within segments;

(1) Polyvalent capacity is privately transferable within its segment. Where an applicant for a polyvalent fishing licence has evidence of holding such capacity (a capacity assignment note) and has an approved fishing vessel then a fishing licence will be issued to such an applicant. This applies to over 18 m and under 18 m sub-segments.
(2) Excluding the fisheries licenced by secondary permit the polyvalent capacity is not coupled to any given quota or entitlement. The capacity assignment note simply enables the vessel owner to complete the registration of a vessel.
(3) In the case of fisheries fished with a permit or secondary licence the authorisation to fish such stocks is effectively coupled with the capacity if the capacity is transferred i.e. this transfer is essentially a transfer of track record in the particular fishery. Such entitlement is, however, also governed by TAC & Quota and any other policies or harvest control rules that might apply to those stocks.
(4) Polyvalent potting capacity is not transferable within its segment other than to first degree relatives of the person to which the capacity was originally assigned.
(5) Polyvalent general capacity that is not attached to a registered vessel for a period of more than 2 years expires.
(6) When polyvalent potting capacity is no longer attached to a registered vessel then the capacity reverts to the licencing authority. This capacity is not re-issued other than to first degree relatives.

2.4 Vessels targeting Shellfish

The shellfish fleet is here defined as vessels under 13 m in length as the vast majority of such vessels depend largely on shellfish. This cut off, however, is not reflective of any licencing or policy condition and many of these vessels also fish for other species. In addition a number of vessels over 18 m target crab mainly in offshore waters (vivier vessels) and 13 vessels over 10 m in length were authorised to fish for scallops in 2018.

The number of vessels in the Shellfish fleet increased significantly in 2006-2007 as a result of the 'Potting Licence Scheme' which regularised many vessels that were operating outside of the registered fleet prior to 2006. The number of vessels in the polyvalent potting segment is declining year on year due to de-registration or transfer from this restricted segment, which limits fishing entitlement. There were 26 fewer such vessels in 2018 compared to 2017. The number of vessels in the polyvalent general segment increased year on year between 2006 and 2012 by an average of 53 vessels per year. This trend was reversed in the period 2012-2017 during which time the number of vessels declined by 98. Between 2017 and 2018 the polyvalent fleet under 13m fleet increased by 29 vessels. The specific segment, targeting bivalves, increased by 13 between 2017 and 2018 mainly due to increased participation in the razor clam fishery (Table 2.1, Table 2.2, Figure 1).

The average length and capacity of vessels in the polyvalent and specific segments declined between 2006 and 2012. A further decline in the size of specific (bivalve) vessels occurred in 2015. Polyvalent vessels under 13 m in length were on average 0.7GT smaller in 2014 compared to 2007.

Polyvalent potting vessels have higher engine capacities in proportion to their gross tonnage than polyvalent general vessels. Aquaculture and specific vessels have lower engine capacities compared to polyvalent or potting vessels.

Table 2.1. Length and capacity profile of the Irish Shellfish fleet 2006-2018 (<13 m polyvalent, all polyvalent potting, all vessels in specific segment, all aquaculture vessels). Vessels over 18 m fishing for crab and scallop are not included

Year	Aquaculture	Polyvalent General	Polyvalent Potting	Specific	Total
Number of vessels					
2006	3	953	80	97	1133
2007	13	999	490	93	1595
2008	46	1081	482	115	1724
2009	60	1146	474	124	1804
2010	68	1198	467	120	1853
2011	78	1239	461	118	1896
2012	85	1269	460	122	1936
2013	86	1233	454	117	1890
2014	89	1218	448	112	1867
2015	89	1226	426	123	1864
2016	87	1218	404	126	1835
2017	83	1171	363	125	1742
2018	84	1200	337	138	1759
Average length					
2006	7.96	7.95	7.32	9.40	8.03
2007	8.20	7.84	6.76	9.38	7.60
2008	7.41	7.73	6.71	9.32	7.55
2009	7.15	7.65	6.71	9.33	7.50
2010	7.11	7.57	6.67	9.36	7.44
2011	7.23	7.54	6.64	9.39	7.42
2012	7.24	7.51	6.62	9.36	7.41
2013	7.14	7.50	6.62	9.41	7.39
2014	7.15	7.53	6.62	9.52	7.41
2015	7.10	7.53	6.62	9.56	7.44
2016	7.15	7.52	6.59	9.66	7.44
2017	7.09	7.56	6.59	9.70	7.49
2018	7.07	7.52	6.59	9.64	7.49
Average GT per vessel					
2006	3.26	4.68	2.96	7.24	4.78
2007	3.75	4.43	2.29	7.06	3.92
2008	3.29	4.20	2.22	6.88	3.80
2009	2.87	4.08	2.22	6.70	3.73
2010	2.72	3.96	2.16	6.73	3.64
2011	2.85	3.91	2.12	6.80	3.61
2012	2.84	3.85	2.10	6.90	3.58
2013	2.71	3.87	2.11	7.09	3.59

2014	2.72	3.92	2.11	7.14	3.62
2015	2.72	3.95	2.10	7.30	3.69
2016	2.87	3.93	2.09	7.50	3.72
2017	2.77	3.97	2.10	7.73	3.79
2018	2.85	3.89	2.12	7.64	3.79
Average Kws per vessel					
2006	45.45	35.49	44.50	65.64	38.72
2007	53.76	34.43	30.29	62.58	34.96
2008	37.68	32.66	29.79	60.44	33.84
2009	33.86	31.45	29.26	57.57	32.75
2010	31.55	30.43	28.93	59.38	31.97
2011	32.89	30.09	28.28	60.32	31.65
2012	33.65	29.60	28.03	61.55	31.42
2013	32.48	29.61	28.06	64.31	31.52
2014	32.11	30.20	28.23	65.84	31.96
2015	32.17	30.38	27.85	67.15	32.31
2016	30.32	30.19	27.35	68.86	32.22
2017	30.72	30.61	28.22	68.76	32.85
2018	31.53	30.27	28.76	67.77	32.98

Table 2.2. Annual change and percentage change in the numbers of vessels per fleet segment in the under 13 m Shellfish fleet 2006-2018.

Year	Aquaculture	Polyvalent General	Polyvalent Potting	Specific	Total
Change in number of vessels					
2006-2007	10	46	410	-4	462
2007-2008	33	82	-8	22	129
2008-2009	14	65	-8	9	80
2009-2010	8	52	-7	-4	49
2010-2011	10	41	-6	-2	43
2011-2012	7	30	-1	4	40
2012-2013	1	-36	-6	-5	-46
2013-2014	3	-15	-6	-5	-23
2014-2015	0	8	-22	11	-3
2015-2016	-2	-8	-22	3	-29
2016-2017	-4	-47	-41	-1	-93
2017-2018	1	29	-26	13	17
% Change in number of vessels					
2006-2007	333.33	4.83	512.50	-4.12	40.78
2007-2008	253.85	8.21	-1.63	23.66	8.09
2008-2009	30.43	6.01	-1.66	7.83	4.64
2009-2010	13.33	4.54	-1.48	-3.23	2.72
2010-2011	14.71	3.42	-1.28	-1.67	2.32
2011-2012	8.97	2.42	-0.22	3.39	2.11
2012-2013	1.18	-2.84	-1.30	-4.10	-2.38

2013-2014	3.49	-1.22	-1.32	-4.27	-1.22
2014-2015	0.00	0.66	-4.91	9.82	-0.16
2015-2016	-2.25	-0.65	-5.16	2.44	-1.56
2016-2017	-4.60	-3.86	-10.15	-0.79	-5.07
2017-2018	1.20	2.48	-7.16	10.40	0.98

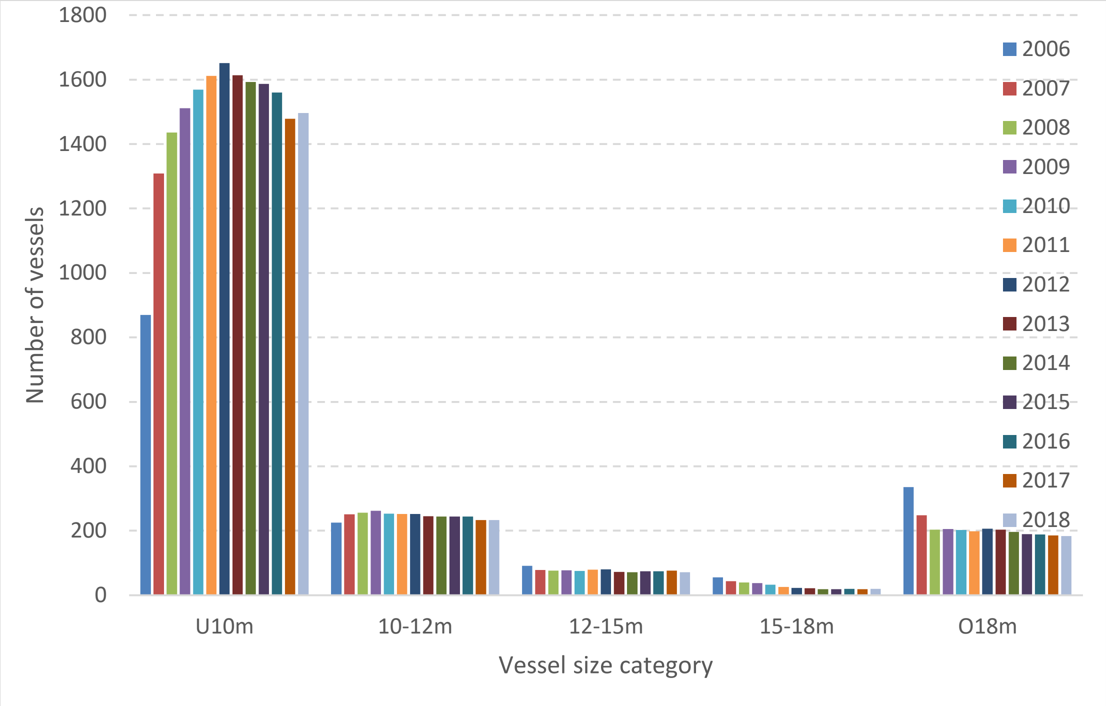

Figure 1. Annual trends in the number of fishing vessels under 13 m in length in four fleet segments 2006-2018.

3 Shellfish Landings 2004-2017

Annual landings of crustaceans and bivalves, excluding *Nephrops* and wild blue mussel (*Mytilus*) seed, which is re-laid for on-growing, during the period 2004-2017, varied from a high of 29,000 tonnes in 2004 to a low of 13,790 in 2009 (Table 3.1).

Landings data for some species (lobster, periwinkle) in recent years show unexpected changes in volumes relative to say 2004 levels. Spider crab in 2012 was substantially higher than in any previous years. Brown crab landings in 2012 were less than half of their value in 2004 but increased substantially in 2016. Lobster landings in 2012 were approximately 30% of 2011 landings. Although landings can obviously increase or decline due to changes in fishing effort or catch rates the scale of change in some species, in fisheries that are known to have stable or increasing effort and where catch rate indicators are stable, is contradictory. Other sources of information from industry questionnaires also indicate significant differences between official landings and landings derived from estimates of catch rates, annual individual vessel landings, days at sea and individual vessel fishing effort.

A number of species such as lobster, periwinkle, native oyster and shrimp are targeted by vessels under 10 m in length. As these vessels do not report landings capturing these data is difficult due to the large number of vessels and the small daily consignments involved. Prior to 2015 these data were captured by the SFAP through information gathering from buyers and post 2015 using the sales notes data.

Landings data for certain species that are subject to management plans (cockle), that are managed locally (oysters) or where SFPA have analysed gatherers dockets and consignment data to buyers (razor clams) provide a complete picture of landings separate to logbook data or sales notes.

In 2016 and 2017 the total volume of shellfish landed increased significantly compared to previous years. This increase was due mainly to higher landings of brown crab and whelk which increased by approximately 4,000 tonnes and 3,000 tonnes, respectively, over 2015. Total value of shellfish, excluding mussel and *Nephrops*, in 2017 was approximately €53million.

Table 3.1. Estimates of annual landings (tonnes) and value (€) of crustacean and bivalve shellfish (excl. prawns and mussels) into Ireland 2004-2017 (source: Logbook declarations and sales notes for vessels under 10m). Unit value (per kilo) is from sales note data or other sources. Figures in bold from www.sfpa.ie

Scientific Name	Common name	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	*2014*	*2015*	*2016*	*2017*	Unit Price 2017	Value 2017
Cancer pagurus	Edible crab	14,217	9,527	10,827	9,251	7,640	6,614	8,622	6,372	6,691	**6,510**	***7,105***	**7,229**	***11,181***	10,284	€1.40	€14,397,600
Pecten maximus	King Scallop	2,471	1,277	742	953	1,322	1,325	1,950	2,203	2,701	3,154	2,834	2,209	2,464	2,649	€4.03	€10,675,470
Homarus gammarus	Lobster	856	635	625	308	498	431	477	735	249	374	*456*	371	398	399	€15.00	€5,985,000
Littorina littorea	Periwinkle	1,674	1,139	1,210	609	1,141	1,103	1,280	64	103	218	1,135				€2.45	€0
Buccinum undatum	Whelk	7,589	4,151	3,144	3,635	1,947	2,239	2,976	2,828	3,440	2,660	2,172	3,296	**6,292**	5,089	€1.62	€8,244,180
Palaemon serratus	Shrimp	405	151	319	325	180	228	135	111	152	157	*301*	250	361	307	€15.10	€4,635,700
Ostrea edulis	Native oyster	543	94	233	291	88	327	349	100	*100*	214	265	153	190	168	*€4.50*	€756,000
Aequipecten opercularis	Queen scallop	110	75	172	26	4		748	1,002	1,479	285	*100*	31	205	48	€0.90	€43,200
Necora puber	Velvet crab	291	245	281	142	268	205	342	160	168	365	*283*	406	289	301	€2.03	€611,030
Spisula	Surf clam	28		26	14	55	150	*162*	*73*	15	37	*67*	48	51	45	€3.00	€135,000
Maja brachydactyla	Spider crab	180	141	153	70	153	443	415	290	818	229	*210*	190	108	118	€1.07	€126,260
Palinurus elephas	Crayfish	80	30	34	16	18	28	30	25	33	34	*23*	25	8	9	€32.90	€302,680
Ensis spp	Razor clams	400	404	547	356	451	293	410	473	428	723	1,040	840	927	1,005	€6.10	€6,130,500
Chaceon affinis	Red crab	214	294	152	83	44	105	91	106	0	0	*0*	33	6	0	€1.30	€130
Carcinus maenas	Shore crab	268	27	46	91	72	244	129	74	253	31	*49*	30	165	154	€0.43	€66,220
Cerastoderma edule	Cockle	207	107	7	643	9	173	5	401	400	374	*3*	0	321	442	€1.85	€817,700
Veneridae	Venus clam		217	4													€0
Total		29,533	18,514	18,522	16,813	13,890	13,908	18,121	15,017	17,030	15,365	16,043	15,111	22,966	21,018		€52,926,670

4 Overview of Management Measures, Stock Status and Exploitation Status

4.1 Marine Strategy Framework Directive (MSFD) Descriptor 3 (Fisheries)

The MSFD requires that Good Environmental Status (GES) is achieved for commercial fish and shellfish by 2020. The GES assessments are to be based on criteria and standards laid down in Commission Directive 2017/845 and Commission Decision 2017/848. The target for GES is that populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock. The exploitation status and population status of these stocks will be described by 3 primary criteria

1. D3C1; Fishing mortality rates (F) relative to F at maximum sustainable yield (MSY) (F_{msy})
2. D3C2; Spawning Stock Biomass (SSB) relative to the SSB that is capable of delivering MSY (B_{msy})
3. D3C3; Age and size distribution of fish in the population is indicative of a healthy population and to include a high proportion of old/large fish

The first two primary state criteria (F, SSB) are compared against the MSY target and imply, therefore, that MSY or reference points framed with respect to MSY are known. It is not sufficient to simply know the status of the criteria but to frame these against a management target (MSY) or reference points that indicate position relative to MSY. These criteria are not new or specific to MSFD. They are the basis for advice on management of fish stocks in Europe under the Common Fisheries Policy and the MSY objective of course pre-dates the MSFD and Commission Decision 2017/848. As such the MSFD is integrating existing methods and benchmarks that form the basis of existing fisheries advice.

For many of the Shellfish stocks reported here MSY, and reference points relative to MSY, have not yet been estimated. This is due to a combination of factors such as the short data time series that are available for many stocks, lack of age data, spatial variability in biological characteristics, strong environmental effects on recruitment and poorly developed stock assessment methods for such stocks. This is also the case with many finfish stocks which are categorised as ‘data poor’ (ICES Stock categories 3-6).

In the case of data poor stocks Commission Decision 2017/848 allows for proxy indicators of F and SSB as follows

1. D3C1; Fishing mortality can be defined as trends in catch/biomass ratio. Other variables could also be envisaged and are used to report on the exploitation status of shellfish in this review
2. D3C2; Spawning stock biomass can be reported as trends in biomass related indices (catch per unit effort, survey indices)
3. D3C3; proportion of fish greater than size at maturity, proportion of large fish (95th percentile). Following advice from ICES, until the proof of concept has been validated for this criterion, the Marine Institute does not include this in its assessment.

These criteria for GES are to be reported under MSFD Descriptor 3 on a 6 year cycle. Attainment of GES for shellfish stocks is based solely on criteria D3C1 and D3C2, on a one-out-all-out (OOAO) basis, following ICES advice. Therefore, a stock should meet the appropriate values on both criteria to be considered compliant with GES.

4.2 Exploitation and Stock Status criteria for Shellfish

4.2.1 Description

Proxy primary criteria for stock status of Shellfish are derived from commercial or survey based trends.

Criteria for exploitation status and stock status (Table 4.1), identifying the degree to which either technical measures or catch controls, including annual TAC, constrains exploitation are described as

- Exploitation status
  - The spawning potential ratio (SPR) which defines the ratio of spawning under current (likely) fishing mortality rate to that of an unexploited stock (B_o). Limit and target reference points for SPR are generally accepted to be 0.1 and 0.35 respectively based on meta-analysis of fish stocks response to exploitation. Hence 0.35*$SPRB_o$ corresponds to B_{msy}. Where the SPR is not defined analytically it can be described by the relationship between size at maturity and size at first capture (Minimum Landing Size or Minimum Conservation Reference Size, MCRS) especially where discard mortality is negligible as is the case for most shellfish. All shellfish have an MCRS which is designed to enable some spawning escapement and which provides for a given SPR.
  - The harvest ratio (HR) or catch biomass ratio, which is the proportion of the biomass, removed annually. HR corresponding to F_{msy} will vary between stocks i.e. some species can sustain higher levels of F or HR than others. For stocks where reference points are unavailable the sustainable HR is unknown. In these cases the response of the stock to the HRs, and which are controlled by TAC, are monitored over time and adapted.
- Stock status
  - Stock biomass can be described directly from surveys, where such surveys provide estimates of absolute biomass, and by proxies such as biomass indicators from surveys or catch per unit effort (CPUE) from commercial data. The stock status relative to B_{msy} is not generally known but proxies could include trends in surveys or CPUE and comparison of current or recent position against long term trends. This should, however, be qualified given that the historic trend is likely to already represent an exploited stock time series and true Bo (unexploited) or B_{msy} remains unknown. These time series can also be analysed using various stock assessment procedures and may provide estimates of B_{msy}.

Four categories or combinations of stock status-exploitation status criteria can be described. Reference to low and high in these categories, described below, is usually defined by the ratio of current F or SSB relative to F or SSB MSY reference points. For shellfish, therefore, where these reference points are not available the categorisation is based on trends in the case of stock status or in the case of exploitation status can be described in terms of SPR, HR controls or size at first capture.

1. Both exploitation status and stock status are deemed to be low:
   - This describes stocks which have not recovered from previously higher levels of exploitation or which have suffered recruitment impairment or high mortality independent of fishing mortality. Persistently low stock levels may infer that the exploitation levels even if they are regarded as low are inappropriate, that other

sources of mortality exist or that the stock recruitment relationship has fundamentally changed.

2. Exploitation levels are low and stocks are productive.
   - These are deemed to be sustainably fished stocks.
3. Exploitation levels are high and stock status is low.
   - These stocks are deemed to be fished at unsustainable levels.
4. Exploitation is high and stocks are productive.
   - This could refer to stocks with a short history of exploitation for instance. The stock is unlikely to remain productive over the long term if exploitation rates are not reduced.

Table 4.1. Fishing mortality and spawning stock biomass indicators. How the proxies for fishing mortality and stock size translate to D3C1 and D3C2, respectively. Red; does not meet that criterion. Green; does meet that criterion; Grey; unknown

Indicator	Description	Threshold	Category
Fishing Mortality (exploitation rate) D3C1	$SPR_{35\%}$ = Target reference point based on meta-analysis	≥35%	1
		<35%	0
	Harvest Ratio or Catch/Biomass ratio	Stock specific	1
			0
Spawning Stock Biomass D3C2	CPUE ratio; Nominal average $CPUE_{recent\ 3\ years}$/average $CPUE_{time\ series}$	≥1	1
		<1	0
	$B_{survey\ trend}$; trends in biomass estimates from surveys	≥1	
		<1	0

4.2.2 Quality of the criteria

4.2.2.1 Exploitation status

Biological data on size at maturity is usually available. Size at first capture is defined by MCRS (landing sizes) in most cases and discard mortality for most species of shellfish is low. There is high confidence in these cases that SPR or spawning escapement below the size at first capture is protected.

The SPR ratio is dependent on knowing the current position with respect to an analytically derived estimate of annual fishing mortality rate (F). F is derived essentially from the size frequency distribution of fully recruited size classes combined with information on growth. For shellfish the shape of the size frequency can be highly variable spatially which complicates sampling and assessment of F. Growth parameters also vary spatially and construction of growth curves in these scenarios is difficult.

For species regulated by TAC there is a constant harvest strategy. The harvest rate is not estimated with respect to a reference point or forecast but is simply a given proportion of the stock biomass estimated from survey. Over time the response of the stock to these harvest rates can be estimated and harvest rates adjusted. There is a degree of adaptive management in these cases. Protocols developed by the Inshore Management Group and Industry for exploitation of new fisheries for bivalves sets out the approach to management of these fisheries and the need for precaution when reference points are unknown.

4.2.2.2 Stock status

Trends in stock status indicators derived from commercial data are currently reported as nominal time series i.e. observed data. These series can drift over time which may lead to bias i.e. the indicator may not be a true reflection of changes in stock. This might be due to changes in catchability, changes in technology on board vessels or some environmental change that alters the relationship between the indicator and the underlying stock status. To offset this the nominal time series should be standardised to remove effects of changes in catchability. Work is ongoing in this area.

Indicators or absolute estimates of biomass from surveys are reported as trends but not in relation to reference points. Stable or positive trends in these series do not infer that stock status is at MSY but show recent status against the longer term mean if the time series is available. The survey time series for shellfish is quite short. These trends are therefore only indicative of improving, stable or deteriorating status based on direction of change in the indicator.

4.2.3 Current Status by Species

Stock and exploitation status indicators by Species and stock unit are reported in Table 4.2.

Edible crab: The MCRS of 130mm (140mm from Feb 2019) is higher than $SOM_{50\%}$ (which is 120mm) and protects SPR and spawning potential, because discard survival is high. Stock status, as measured by LPUE time series, may be declining in areas where effort is increasing but this is unlikely to be due to recruitment overfishing and more likely to be caused by high in season harvest rates and in season stock depletion. Gear saturation effects also influence the LPUE indicator i.e. as the amount of gear increases LPUE declines even if the stock status is unchanged.

Scallop: The MCRS of 100mm or 110mm is higher than $SOM_{50\%}$ and protects SPR. Discard or dredge contact mortality, however, reduces the effectiveness of the MCRS. Commercial CPUE indicators show positive trends in all areas other than the Celtic Sea. There may be some technology creep in the CPUE series due to increased use of ground discrimination technology.

Lobster: The MCRS of 87mm is less than $SOM_{50\%}$ and does not protect SPR sufficiently. The combined technical measures of MCRS, MaxCRS (127mm) and v-notching provides SPR between 10 and 35%. CPUE, LPUE and UPUE (recruitment) indicators generally show positive trends.

Whelk: The MCRS (45mm) is significantly less than $SOM_{50\%}$. SPR is poorly protected. Stock trends are unknown.

Shrimp: Seasonal closures and grading at sea (voluntary) protect against growth and recruitment overfishing. Stock status is recruitment dependent and this is highly variable and environmentally driven.

Native oyster: MCRS is higher than $SOM_{50\%}$ and protects SPR. Natural mortality rate is often high in areas infested by *Bonamia ostrea* or unsuitable environmental conditions. HR on legal size oysters is extremely high in most areas. Stocks outside of Tralee Bay are depleted although survey biomass estimates are generally stable. Landings are low relative to historic levels.

Queen scallop: Biomass, landings and CPUE in the North Irish Sea are all declining. Strong recruitment in 2010-2013 led to increased landings and effort. The stock is depleted.

Velvet crab: Recent introduction of MCRS at 65 mm will protect future spawning potential. Stock status unknown. Depleted in some areas.

Spider crab: The MCRS protects spawning potential. Targeted fishery in Tralee Bay and by-catch elsewhere. Range and distribution may have expanded recently.

Spiny lobster: MCRS is higher than $SOM_{50\%}$ and protects SPR. The stock is depleted. Landings low relative to historic levels.

Surf clam. Waterford estuary survey trend stable. HR limited to 15% of standing stock. Status of other stocks unknown but many of them are not currently exploited.

Razor clams

- North Irish Sea: SPR declining, landings higher than catch advice, survey trend (2 years) negative, longer term trends in commercial LPUE negative.
- South Irish Sea
    - Rosslare: Closed, survey trends show increasing biomass and strong recruitment.
    - Curracloe: Status unknown. Survey pending.
    - West coast stocks: Survey trends stable. HR constrained at 15%

Cockle

- Dundalk Bay: Survey trends positive, HR constrained at 33%. Other closure conditions in place to protect habitats and birds.
- Castlemaine and Drumcliffe Bay: Status unknown. Landings are low.

Table 4.2. Stock and exploitation status for shellfish stocks based on indicators described in Table 4.1

Species	Stock Unit	Fishing method	Data source	Management measures	MSFD DC31; Exploitation status	MSFD D3C2; Stock status	Exploitation status	Stock status
Edible crab *Cancer pagurus*	Malin Shelf	Trap	CPUE, Sea and Port sampling	MCRS 130mm, KWDay limit	MCRS>SOM_{50}; SPR>$SPR_{35\%}$ at probable F	CPUE ratio;		
	South West	Trap	CPUE, Sea and Port sampling	MCRS 130mm, KWDay limit	MCRS>SOM_{50}; SPR>$SPR_{35\%}$ at probable F	CPUE ratio;		
	South East	Trap	CPUE, Sea and Port sampling	MCRS 130mm, KWDay limit	MCRS>SOM_{50}; SPR>$SPR_{35\%}$ at probable F	CPUE ratio;		
	North Irish Sea	Trap	CPUE, Sea and Port sampling	MCRS 130mm, KWDay limit	MCRS>SOM_{50}; SPR>$SPR_{35\%}$ at probable F			
King Scallop *Pecten maximus*	Celtic Sea	Dredge	CPUE, Sea and Port sampling	MCRS 100-110mm, Kwday limit	MCRS>SOM_{50}	CPUE ratio; 0.9, ↓		
	SW Irish Sea	Dredge	CPUE, Sea and Port sampling	MCRS 100-110mm, Kwday limit	MCRS>SOM_{50}	CPUE ratio; 1.1, ↑		
	NE Irish Sea	Dredge	CPUE, Sea and Port sampling	MCRS 100-110mm, Kwday limit	MCRS>SOM_{50}	CPUE ratio; 1.2, ↑		
	NW Irish Sea	Dredge	CPUE, Sea and Port sampling	MCRS 100-110mm, Kwday limit	MCRS>SOM_{50}	CPUE ratio; 1.6, ↑		
	Eastern Channel	Dredge	CPUE, Sea and Port sampling	MCRS 100-110mm, Kwday limit	MCRS>SOM_{50}	CPUE ratio; 1.1, ↑		
	SW Ireland	Dredge	CPUE, Sea and Port sampling	MCRS 100-110mm, Kwday limit	MCRS>SOM_{50}	CPUE ratio; 1.5, ↑		
Lobster *Homarus gammarus*	Mayo Donegal	Trap	CPUE, Sea and Port sampling	MCRS 87mm, MaxLS 127mm, v-notch	MCRS<SOM_{50}; SPR10%<SPR<SPR35%	CPUE ratio; 1.3, ↑		
	Clare Galway	Trap	CPUE, Sea and Port sampling	MCRS 87mm, MaxLS 127mm, v-notch	MCRS<SOM_{50}; SPR10%<SPR<SPR35%	CPUE ratio; 0.7, ↓		
	Kerry	Trap	CPUE, Sea and Port sampling	MCRS 87mm, MaxLS 127mm, v-notch	MCRS<SOM_{50}; SPR10%<SPR<SPR35%	CPUE ratio; 1.4, ↑		
	Cork	Trap	CPUE, Sea and Port sampling	MCRS 87mm, MaxLS 127mm, v-notch	MCRS<SOM_{50}; SPR10%<SPR<SPR35%	CPUE ratio; 1.3, ↑		
	Waterford Wexford	Trap	CPUE, Sea and Port sampling	MCRS 87mm, MaxLS 127mm, v-notch	MCRS<SOM_{50}; SPR10%<SPR<SPR35%	CPUE ratio; 1.5, ↑		
	North Irish sea	Trap	CPUE, Sea and Port sampling	MCRS 87mm, MaxLS 127mm, v-notch	MCRS<SOM_{50}; SPR10%<SPR<SPR35%	CPUE ratio; 1.1, ↑		
Whelk *Buccinum undatum*	South Irish Sea	Trap	CPUE, Port sampling	MCRS 45mm height	MCRS<SOM_{50}	Unknown		
	Inishowen	Trap	Port sampling	MCRS 45mm height	MCRS<SOM_{50}	Unknown		
Shrimp	Wexford	Trap	No current program	Season Aug-Mar,	SPR>$SPR_{35\%}$ at probable F	Short lived, recruitment		

Table 4.2. Stock and exploitation status for shellfish stocks based on indicators described in Table 4.1 (continued)

Palaemon serratus				Grading at sea		dependent		
	Galway Bay	Trap	No current program	Season Sept-Mar, Grading at sea	SPR>$SPR_{35\%}$ at probable F	Short lived, recruitment dependent		
	Clew Bay	Trap	No current program	Season Aug-Mar, Grading at sea	SPR>$SPR_{35\%}$ at probable F	Short lived, recruitment dependent		
	Connemara	Trap	No current program	Season Aug-Mar, Grading at sea	SPR>$SPR_{35\%}$ at probable F	Short lived, recruitment dependent		
	West Donegal	Trap	No current program	Season Aug-Mar, Grading at sea	SPR>$SPR_{35\%}$ at probable F	Short lived, recruitment dependent		
	North Irish Sea	Trap	No current program	Season Aug-Mar, Grading at sea	SPR>$SPR_{35\%}$ at probable F	Short lived, recruitment dependent		
	Shannon	Trap	No current program	Season Aug-Mar, Grading at sea	SPR>$SPR_{35\%}$ at probable F	Short lived, recruitment dependent		
	Tralee	Trap	No current program	Season Aug-Mar, Grading at sea	SPR>$SPR_{35\%}$ at probable F	Short lived, recruitment dependent		
	Bantry	Trap	No current program	Season Aug-Mar, Grading at sea	SPR>$SPR_{35\%}$ at probable F	Short lived, recruitment dependent		
	Kenmare	Trap	No current program	Season Aug-Mar, Grading at sea	SPR>$SPR_{35\%}$ at probable F	Short lived, recruitment dependent		
	Roaringwater	Trap	No current program	Season Aug-Mar, Grading at sea	SPR>$SPR_{35\%}$ at probable F	Short lived, recruitment dependent		
Native oyster *Ostrea edulis*	Lough Swilly	Dredge	Survey	MCRS 76mm	HR>MCRS>90%	Depleted; $B_{survey\ trend}$ →=1		
	Blacksod Bay	Dredge	Survey	MCRS 76mm	HR>MCRS>90%	Depleted; $B_{survey\ trend}$ →=1		
	Achill	Dredge	No current program	MCRS 76mm	Unknown	Unknown		
	Clew Bay	Dredge	Survey	MCRS 76mm	HR>MCRS>90%	Depleted; $B_{survey\ trend}$ →=1		
	Kilkieran Bay	Dredge	Survey	MCRS 76mm	HR>MCRS>90%	Depleted; $B_{survey\ trend}$ →=1		
	Galway Bay	Dredge	Survey	MCRS 76mm	HR>MCRS>90%	Depleted; $B_{survey\ trend}$ →=1		
	Tralee Bay	Dredge	Survey	MCRS 78mm, annual TAC	HR>MCRS>90%	Productive; $B_{survey\ trend}$ →=1		
Queen scallop *Aequipecten opercularis*	North Irish Sea	Trawl	UK assessment	MCRS 40mm	F>Fmsy	SSB<B_{lim}		
	Inishowen	Trawl	No current program	MCRS 40mm	Unknown			
Velvet crab *Necora puber*		Trap	Commercial CPUE, Observer	MCRS 65mm	MCRS>SOM_{50}	Unknown		
Surf clam *Spisula solida*	Waterford Harbour	Dredge	Survey	MCRS 25mm, annual TAC	HR 0.15	Productive; $B_{survey\ trend}$ →=1		
	Clifden Bay	Dredge	No current program	MCRS 25mm				

Table 4.2. Stock and exploitation status for shellfish stocks based on indicators described in Table 4.1 (continued)

	Galway Bay	Dredge	No current program	MCRS 25mm				
Spider crab *Maja brachydactyla*	Tralee Bay	Trap	No current program	MCRS 130mm Male, 125mm female	MCRS>SOM_{50}	Unknown		
Crayfish *Palinurus elephas*	South west	Tangle net	Commercial CPUE, Observer	MCRS 110mm, Closed area to netting	MCRS>SOM_{50}	Depleted; Trend unknown		
Razor clams *Ensis siliqua*	North Irish Sea	Hydraulic Dredge	Survey	MCRS 125mm	SPR10%<SPR<SPR35%, HR=0.2	$B_{survey\ trend}$ ↓<1, CPUE ratio; 0.7, ↓		
	Rosslare	Hydraulic Dredge	Survey	MCRS 125mm	SPR<SPR10%, HR = 0. Closed.	Re-building		
	Curracloe	Hydraulic Dredge	Commercial CPUE	MCRS 125mm	Unknown	Survey pending		
	Waterford Estuary	Hydraulic Dredge	Survey	MCRS 100mm, annual TAC	HR 0.15	$B_{survey\ trend}$ →=1		
Razor clams *Ensis magnus*	Clifden Bay	Hydraulic Dredge	Survey	MCRS 100mm, annual TAC	HR 0.15	$B_{survey\ trend}$ →=1		
	Ballinakill	Hydraulic Dredge	Survey	MCRS 100mm, annual TAC	HR 0.15	$B_{survey\ trend}$ →=1		
	Inisbofin/Killary	Hydraulic Dredge	Survey	MCRS 100mm, annual TAC	HR 0. Closed pending survey	$B_{survey\ trend}$ →=1		
	Iniskea Is	Hydraulic Dredge	Survey	MCRS 100mm, annual TAC	HR 0. Closed, pending survey	$B_{survey\ trend}$ →=1		
Shore crab *Carcinus maenas*		Trap	No current program	None	Unknown	Unknown		
Cockle *Cerastoderma edule*	Dundalk Bay	Hydraulic Dredge	Survey	MCRS 22mm, TAC, CPUE rate closure, season	HR 0.33	$B_{survey\ trend}$ ↑>1		
	Drumcliffe Bay	Hand Gathering		None	Unknown	Unknown		
	Castlemaine Hbr	Tractor dredge		None	Unknown	Unknown		

5 Razor clam (*Ensis siliqua* and *Ensis magnus*)

5.1 Management advice

All commercially exploited razor clam stocks are assessed by survey which provide estimates of biomass by size or grade. Weekly TACs apply to vessels in the north and south Irish Sea. All vessels report iVMS data. Voluntary TAC agreements and management plans were in place for Clifden Bay, Waterford Estuary and Ballinakill Bay in 2018 based on advisory 15% harvest rate. These smaller scale fisheries operated successfully in 2018 under voluntary measures.

The north Irish Sea fishery expanded significantly in the period 2011-2018. All indicators (daily landings per vessel, catch per hour) show significant and persistent declines over time. Surveys in 2017 and 2018 indicated a biomass of 6,471 and 5,344 tonnes, respectively, and an approximate annual exploitation rate of 10%. Large size classes are being depleted and the fishery is increasingly reliant on small and less valuable clams due to growth overfishing. The Spawning Potential ratio (SPR) has declined over time as the average size and abundance of larger clams has declined. Depletion corrected average catch (DCAC) assessment for the North Irish Sea indicates that landings should be significantly reduced from current levels; current estimates, with some assumptions, suggest a reduction to 360 tonnes per annum.

Landings and effort in the North Irish Sea in 2016 and 2017 were similar but declined in 2018. The number of vessels in the fishery increased from 49 in 2015 to 73 in 2016 and 2017 and 59 in 2018. The decline in landings and number of participating vessels in 2018 may indicate increasingly difficult conditions in the fishery. Time and cost to catch weekly quotas increased, due to declining catch rates.

The south Irish Sea fishery opened in 2010 and expanded quickly to 2013. Annual landings declined from 2013-2018. The Rosslare fishery was closed by voluntary agreement in 2017 and 2018 due to low biomass of commercial clams. A strong recruitment event in 2014 (probably) was observed in the 2017 survey and increased in biomass significantly between 2017 and 2018 surveys. New management arrangements to avoid overfishing of this biomass should be developed.

Many razor clam fisheries or potential fisheries occur within or close to Natura 2000 sites. The conservation objectives for species and habitats in these areas are integrated into Razor clam fishery management plans on the west coast and pressures and impacts of the fishery on seafloor habitats are monitored in the Irish Sea.

5.2 Issues relevant to the assessment of the razor clam fishery

Razor clams (*Ensis siliqua*) occur along the east coast of Ireland in mud and muddy sand sediments from Dundalk to Dublin and from Cahore to Rosslare and in numerous areas along the west coast. A second species, *Ensis magnus*, is abundant in clean sand substrates on the west coast. Both species may occur in the same area. The distribution is currently known from the commercial fishery which operates in water depths of 4-14 m and from surveys where there are no fisheries. Fishing depth is limited because of the fishing method which uses hydraulically pressurised water to fluidise sediments in front of the dredge. The distribution of razor clams may extend to deeper water outside of the range of the fishery as the species occurs at depths of up to 50 m. However, there is no evidence that significant biomass occurs outside of those areas already fished.

The efficiency of the hydraulic dredge used in razor clam fisheries in the UK has been measured at 90%. The dredge, therefore, is very efficient at removing organisms in the dredge track. This is in contrast to non-hydraulic dredges used in other bivalve fisheries such as scallop and oyster where dredge efficiency may be in the region of 10-35%. Discard mortality rates are unknown but may be significant given that damage can be observed on the shell of discarded fish and unobserved shell damage may occur at the dredge head.

Ensis siliqua is slow growing, reaches a maximum shell length of approximately 220 mm and has relatively low productivity. The apparent resilience to date of the species in areas subject to persistent fishing by highly efficient gears may possibly be explained by immigration of juvenile and adult razor clams from areas outside of the fishery. Some evidence of size stratification by depth has been shown in Wales and given the known mobility of the species suggests that post settlement movement and recruitment into fished areas may occur. *Ensis magnus* is faster growing, occurs in higher densities and reaches a smaller maximum size than *E. siliqua*.

Physical disturbance of sediments and removal of *Ensis* by the fishery potentially alters the bivalve species composition and generally the faunal communities in benthic habitats. In shallow waters changes in the abundance and species composition of bivalves may have a negative effect on diving seaducks (Common Scoter) that feed on bivalves. This species is designated under the Birds Directive in both Dundalk SPA in Louth and Raven SPA in Wexford. The fishery may also result in changes to habitat due to the deep physical disturbance caused by the hydraulic dredging process.

5.3 Management Units

Stock structure is unknown. Larval dispersal and movement of juveniles and possibly adults suggest that the stock structure is relatively open along the east coast of the north Irish Sea and that individual beds are unlikely to be self-recruiting. Fishing is continuous from north Dundalk Bay to Malahide. Stocks in the south Irish Sea are likely to be separate to that north of Dublin given the different hydrodynamic and tidal regimes in the two areas.

Other isolated stocks occur in many locations on the south and west coasts. Fisheries occur in Clifden Bay, Iniskea Islands in Mayo, Ballinakill Bay and Waterford estuary.

5.4 Management measures

New management measures were introduced for the Rosslare – Cahore fishery in December 2014. These include an increase in MLS from 100 mm to 130 mm, fishing hours from 07:00 to 19:00, 2.5 tonne quota per vessel per week (currently 2,000 kg), 1 dredge per vessel not to exceed 122 cm width and with bar spacing not less than 10 mm, prior notice of intention to fish and advance notice of landing, mandatory submission of gatherers docket information on landings, date and location of fishing, a requirement to transmit GPS position of the vessel on a 1 minute frequency and a defined fishing area to minimise overlap with Natura 2000 sites. The Rosslare Bay fishery was closed by voluntary agreement in 2017 and 2018 due to growth overfishing.

In the north Irish Sea the weekly vessel TAC is 600 kgs (from Jan 1st 2016) with a prohibition on landing on Sundays (SI 588/2015). The fishery is closed in June during the spawning season. The minimum landing size increased to 125 mm in 2018.

Fisheries on the west coast have voluntary TAC arrangements in place based on survey biomass estimates and an agreed harvest rate.

All vessels fishing for Razor clams must have a functioning iVMS system on board and report GPS position at defined frequencies. Only 1 class of production area (A,B,C) can be fished during a fishing trip (SI 206/2015).

5.5 North Irish Sea

The fishery occurs close to the coast in shallow sub-tidal waters along the east coast from Dundalk south to Malahide (Figure 2). Vessel monitoring systems data shows fishing activity from Dundalk Bay to Malahide and at Lambay Island. The distribution of activity has expanded in recent years although the footprint in 2016 and 2017 are largely similar. The areas receiving highest fishing effort varies between years. In 2016 hot spots of activity occurred at Lambay and north of Howth at Malahide. In 2017 effort intensified at Skerries and declined at Lambay and Malahide. Higher levels of activity also occurred between Balbriggan and Clogherhead in 2017 compared to 2016.

5.5.1 Landings

Landings from the north Irish Sea in 2016 and 2017 were the highest on record at 887 and 898 tonnes respectively but declined to just over 500 tonnes (provisional) in 2018. Seventy three vessels fished in 2016 and 2017 but this declined to 59 in 2018 (Figure 3). Average tonnes landed per vessel reached a peak of 18 tonnes in 2014 and was 7.5 tonnes in 2018.

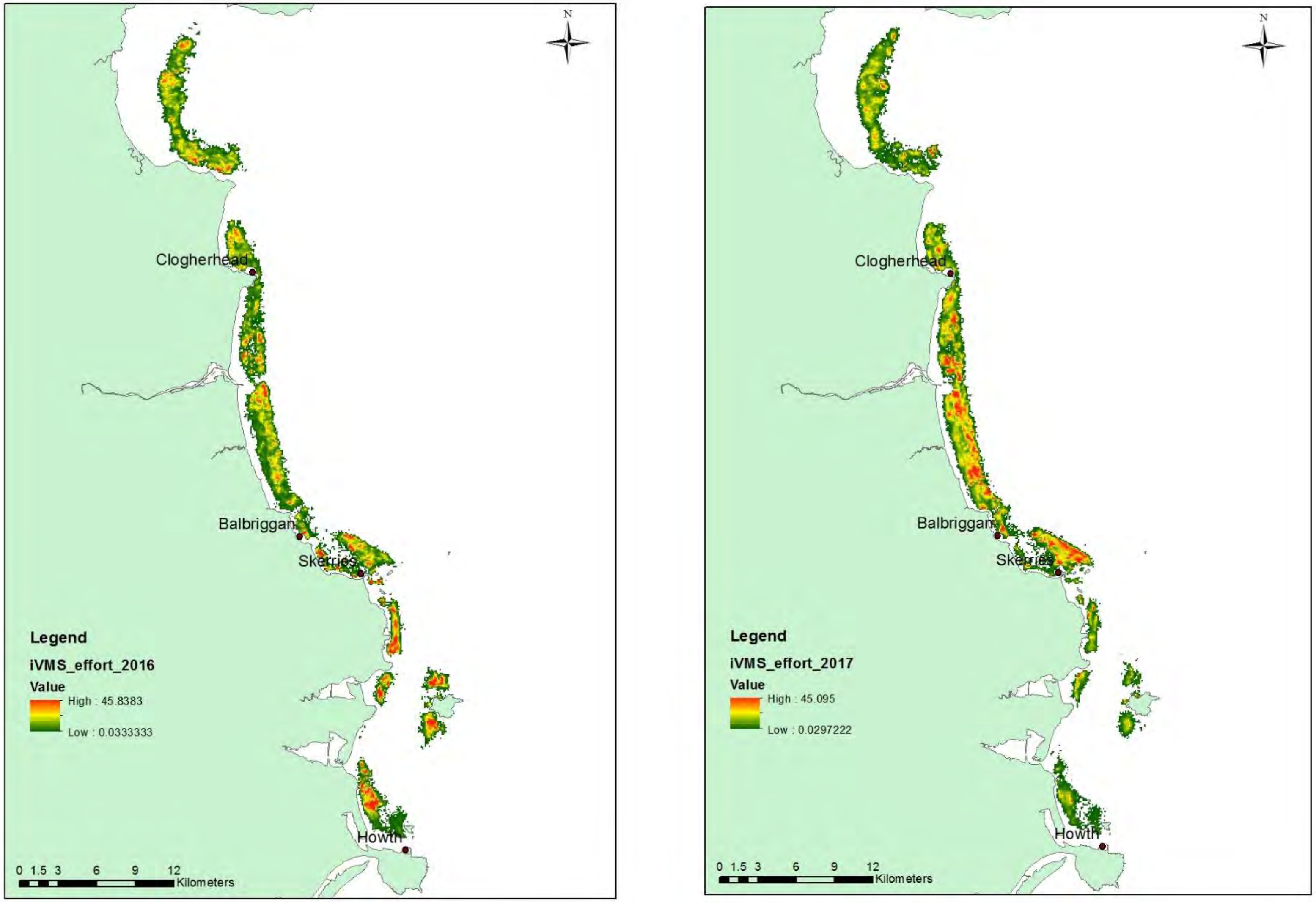

Figure 2. Distribution of fishing for razor clams in the north Irish Sea in 2016 and 2017 from iVMS data.

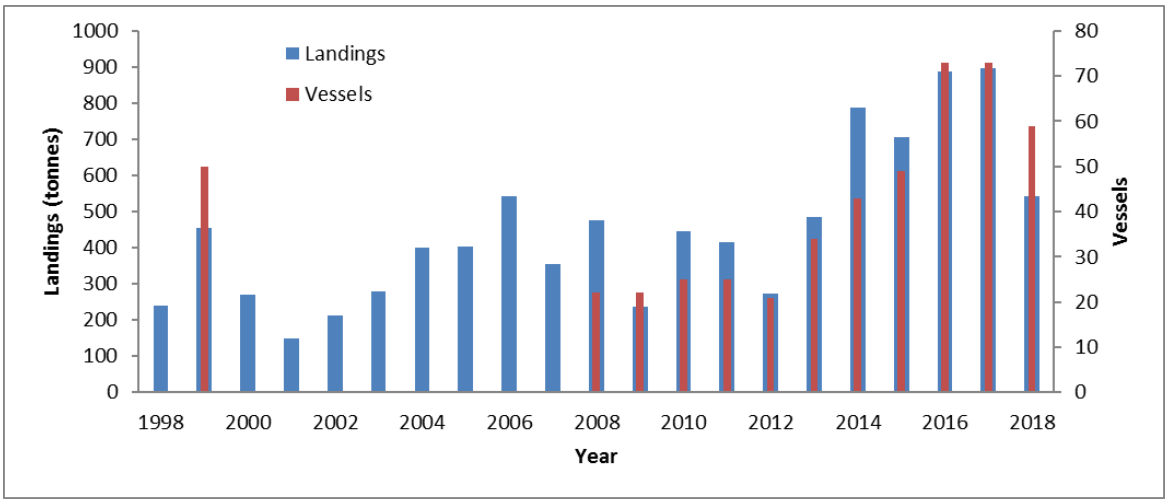

Figure 3. Annual landings of *Ensis siliqua* in the north Irish Sea (NIS) 1998-2018 sourced from SFPA logbook, shellfish gatherers data and sales notes. The number of vessels landing razor clams each year is shown for 1999 and from 2008 to 2018.

5.5.2 Survey 2018

A comprehensive survey encompassing all of the areas which are commercially fished for Razor clams was completed in the north Irish Sea in June 2018. The survey was designed using the 2016 iVMS data which showed the level of fishing effort on a 100 square meter grid. This fishing effort was regarded as a proxy for the abundance of razor clams i.e. most fishing effort is expected to occur where clams are more abundant. For operational purposes and to assign stations to each of the 5 survey vessels, the survey domain, which extended from north Dundalk Bay south to Malahide and Lambay, was divided into 5 areas with approximately 160 stations in each area. Within each area, 4 iVMS effort strata of the same surface area where defined, and 50 stations were randomly assigned within each strata, to ensure an even distribution of randomly assigned grid cells across the range of efforts. The survey was mostly completed over a 3-5 day period, depending on area and vessel.

Biomass at each station was estimated based on density (number of individuals caught per meter squared towed area) multiplied by the mean individual weight calculated from the size distribution at the station and a weight-length relationship. Biomass was then interpolated over a 100 m x 100 m grid using ordinary kriging on log(biomass). Total biomass was then estimated as the sum of mean estimated biomass, using a geostatistical (kriging) model, raised to the surface area of the cells. Ninety-five percent confidence intervals were estimated based upon 250 random realisations of the modelled biomass using conditional Gaussian simulations. This preserves the spatial structure in the biomass, as described by variograms which modelled the spatial autocorrelation and spatial structure in the survey data or how density changes relative to distance between stations.

5.5.2.1 Size distribution

The modal shell size in 2017 was 130 mm with a second smaller mode at 180 mm. In 2018 the modal size was approximately 145-150 mm as a result of annual growth of the main cohort present in 2017 (Figure 4). The mode at 180 mm present in 2017 was absent in 2018 indicating that clams over approximately 170 mm were depleted between 2017 and 2018.

The size distribution reflects both the exploitation rate, growth, mortality and recruitment history of the stock. Unexploited stocks surveyed on the west coast in 2016 show an accumulation of larger size classes typical of long lived species with relatively low natural mortality rates. The size distribution of heavily exploited and economically collapsed stocks, such as the Rosslare Bay stock, is dominated by smaller clams under the commercial size. Comparison of the 2017 and 2018 distributions in the North Irish Sea indicate a continued erosion of larger clams and also an apparent absence of recruitment in the survey area.

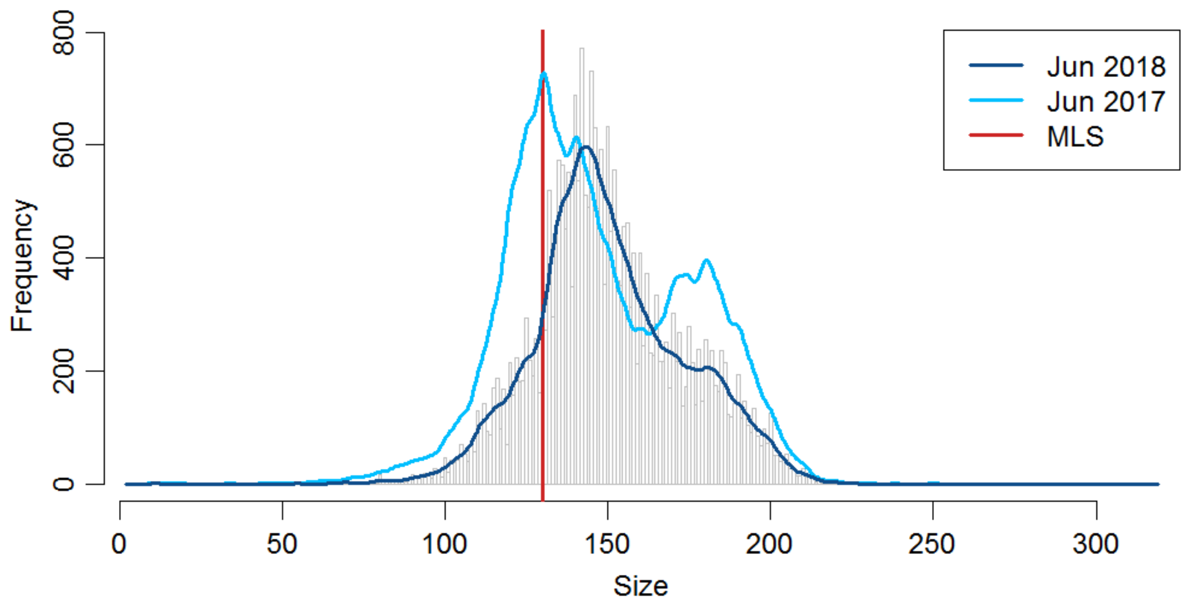

Figure 4. Size distribution, length weight relationship and weight distribution for razor clams in the survey.

5.5.2.2 Biomass

The total biomass in the June 2017 survey was 6,471 tonnes (95% confidence interval: 6,182-6,755 tonnes). Approximately 5,675 tonnes were over the market size of 130 mm (Table 5.1). Biomass of clams over 130 mm in 2018 was 4,009 tonnes representing a decline of over 1,666 tonnes (29%) between June 2017 and June 2018. Landings during this period were approximately 500 tonnes.

Density was lower in the northern part of the survey area in Dundalk Bay, particularly north of the Bay, south of Clogherhead and north of Drogheda. Densities were higher in Skerries and Malahide. These latter areas have been closed to fishing for periods of time in the last number of years. Larger clams over 180 mm were more common in Dundalk bay and Gormanstown. Smaller clams were more abundant off Skerries and Malahide (Figure 5).

Table 5.1. Biomass of razor clams in the North Irish Sea in 2017 and 2018

Biomass (tonnes)	Mean	95% HDI inf	95% HDI sup
2018			
Biomass	4,344	4,075	4,636
Biomass >130mm	4,009	3,772	4,251
2017			
Biomass	6,471	6,182	6,755
Biomass >130mm	5,675	5,405	5,950
Difference			
Biomass	**-2,127**		
Biomass >130mm	**-1,666**		

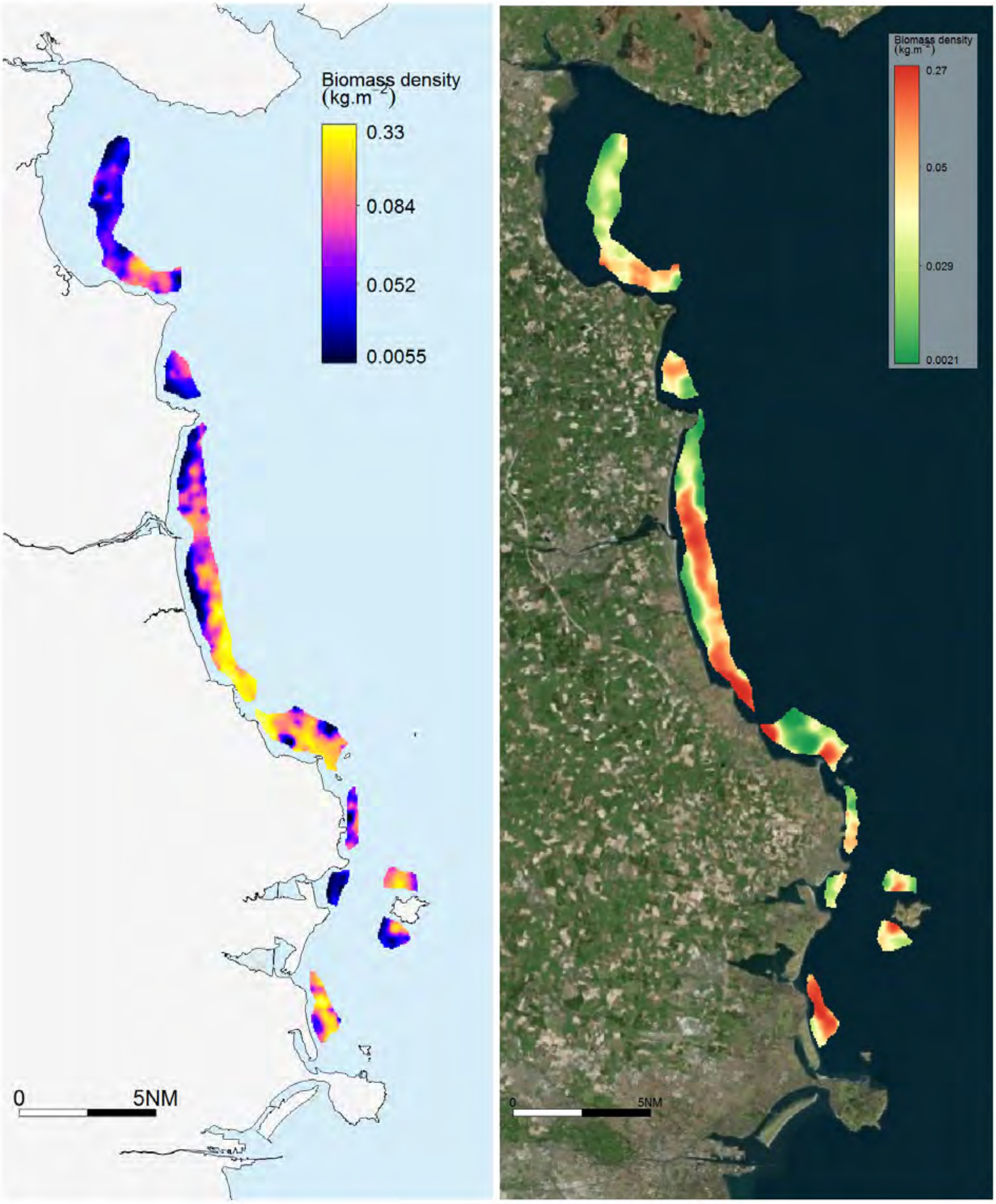

Figure 5. Distribution of biomass of razor clams in the north Irish Sea June 2017 (left) and June 2018 (right).

5.5.3 Stock biomass indicators

Stock biomass indicators (LPUE kgs.day^{-1}, LPUE kgs.hr^{-1}) were estimated from data on consignments to buyers in 2013-2018 and from sentinel vessels 2009-2017. The indicators may be increasingly biased in recent years due to high grading at sea given that the market price increases significantly with size grade and Skippers will try and maximise the value of the weekly quota of 600kgs.

Daily consignments (kgs.day^{-1}) declined from 300 kgs.day^{-1} in early 2013 to 200 by end of 2016 and 174 in Q3 of 2017 (Figure 6). Daily landings reported in SVP logbooks showed a monthly decline of 2.9kgs.day^{-1} in daily landings. Daily landings were between 400-500kgs in 2009-2012 and close to 200 kgs in 2015 and 2017 (Figure 7).

The sentinel vessel data provides a more precise indicator of stock biomass in LPUE per hour of dredging. This varied from 30-40 kgs.hr^{-1} in 2009-2011, declined to 17 kgs.hr^{-1} in 2014-2015, 15 kgs.hr^{-1} in 2016 and 13 kgs.hr^{-1} in 2017 (Figure 8).

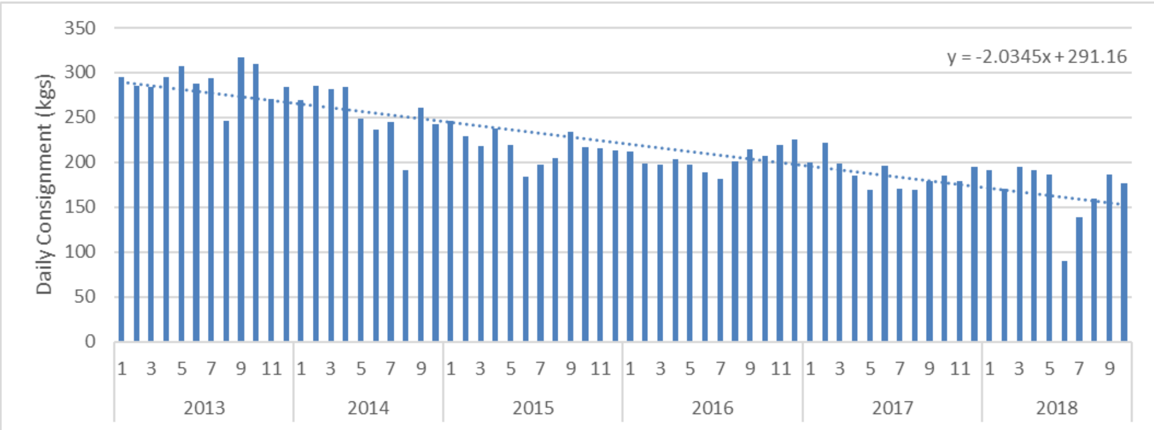

Figure 6. Average daily consignments (kgs) per month recorded in gatherers dockets 2013-2018 showing a rate of decline of 2 kg per day per month in consignment volume. Source: SFPA

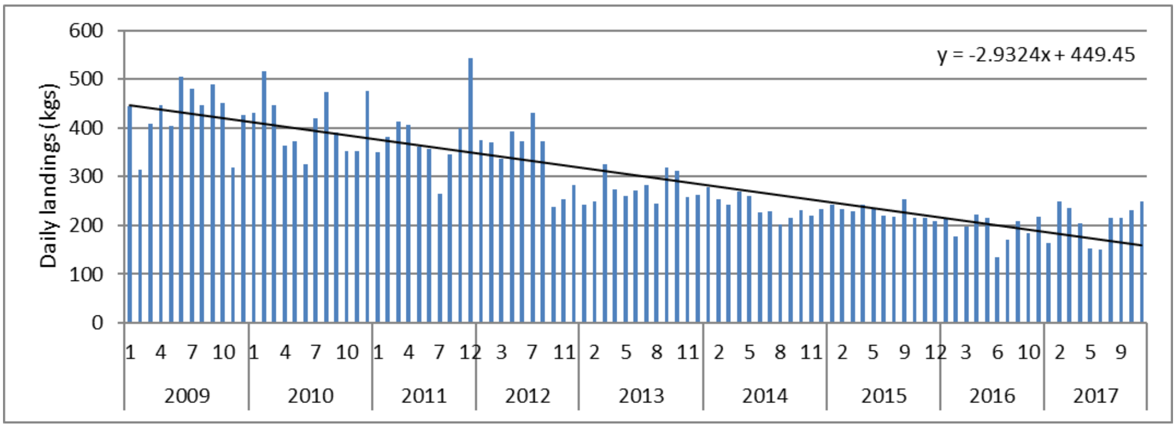

Figure 7. Monthly trends in landings per day by sentinel vessels reporting between 2011 and 2017.

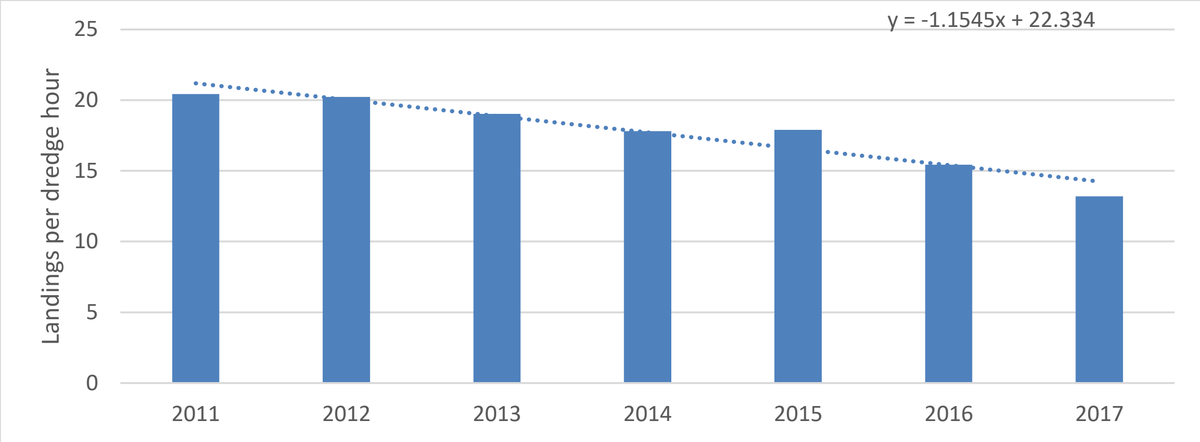

Figure 8. Annual trends in landings per dredge hour by sentinel vessels reporting between 2011 and 2017 in the North Irish Sea.

5.5.4 Depletion corrected catch advice

The DCAC model (MacCall, 2009) estimates the sustainable catch by penalizing the average yearly catches (or landings if survival of the discards is supposed high) based on the observed depletion in abundances indices. The base formula only gives a single estimate, with no confidence interval of the sustainable catch. We have developed a Bayesian implementation of the DCAC model in order to take into account most of the known sources of uncertainty in the assessment of the advisable catch posterior distribution and therefore provide a confidence interval of the sustainable catch in the North Irish Sea. The model was fitted on landing per unit effort (LPUEs) estimated from the sentinel vessel programme (SVP) for the periods 2001-2005 and 2009-2016, as well as LPUEs for the Gormanstown bed from Fahy and Gaffney (2001) (for reference as they estimated 60% of depletion in July 1999).

Landings for each region were estimated as the maximum reported from sales notes and gatherers dockets (when available), from 2001 onwards.

The DCAC model rely on some population specific characteristics which are the natural mortality M, the ratio F/M at MSY and the ratio of the biomass at MSY over the virgin biomass (B_{MSY}/B_0). If M could be estimated from the previously estimated ratio M/k and the k proposed by Fahy and Gaffney (2001), the other parameters needed to be estimated using the LB-SPR model, based on assumptions about the steepness of the stock recruitment relationship (SRR). In the absence of evidence for an impeded recruitment driven by strong exploitation, the steepness of the SRR was assumed high and a prior placing it in the region of 0.7 to 0.9 was used using a beta distribution with a maximum density and mean just below 0.85 (fig. 6). This prior, along with previously assessed LHT and their variability have then been used to generate Monte-Carlo simulations of the theoretical size distribution and associated ratios F_{MSY}/M and SSB_{MSY}/SSB_0 (as a proxy of B_{MSY}/B_0). The distribution fitting the best simulated posteriors of F_{MSY}/M and SSB_{MSY}/SSB_0 (among Normal, log-Normal, Gamma and Weibull) was evaluated (fig. 7) and used as prior for the Bayesian DCAC. These priors, based on a steep SRR, correspond to a high fishing mortality and low biomass at equilibrium for exploitation at a sustainable level and represent therefore an optimistic scenario in terms of sustainable yield.

LPUEs ($kg \cdot h^{-1}$) from gatherer dockets (2001-2016) and extracted from Fahy and Gaffney (2001) were used to estimate the depletion: several Bayesian models describing the trend (year, year+month, year+AR(1mo), year+month+AR(1)) were fitted to the observed CPUEs and compared. The best model was year+AR(1mo) based on the DIC (Figure 9). The posterior distribution of the sustainable yield was generated by the model based on the distributions of F_{MSY}/M (parameter c in MacCall, 2009) and SSB_{MSY}/SSB_0 and the DCAC delta, estimated as: $\Delta = \frac{LPUE_{start} - LPUE_{end}}{LPUE_0}$. The period over which delta was calculated was chosen to avoid data based on too small a subset of vessels prior to 2003 and a suspected severe increase in high grading after 2015 (although this has also likely to have been increasing gradually). The LPUE expected for a virgin population ($LPUE_0$) was estimated based on a 60% depletion in July 1999 (Fahy and Gaffney, 2001).

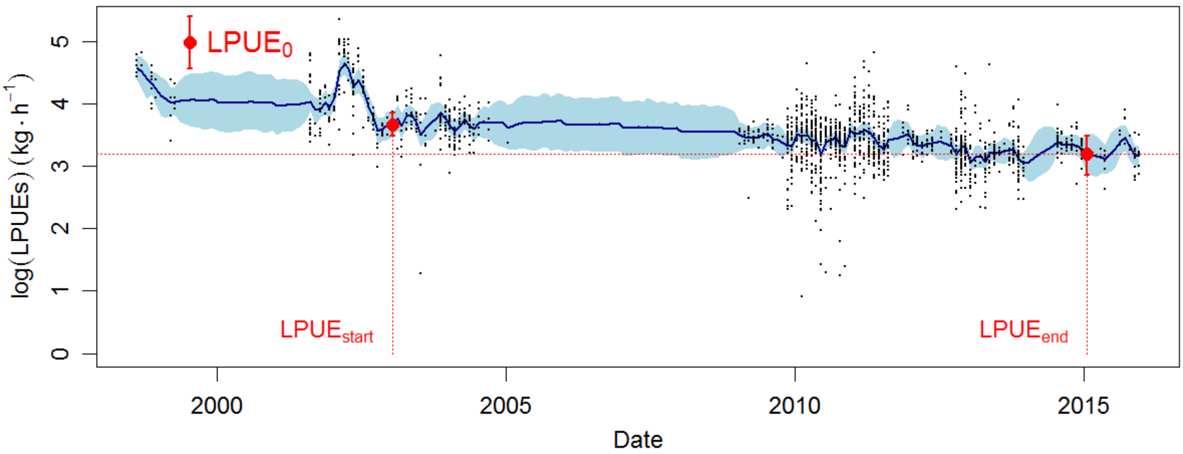

Figure 9. LPUEs fitted by the Bayesian model with a yearly trend and autocorrelation AR(1) between month (blue: mean and 95%CI). The values retained to estimate the delta of the DCAC models are shown in red.

The sustainable yield for the North Irish Sea was estimated, on the base of this optimistic scenario, to be 360 tonnes, with a 95% confidence interval of 301 to 409 tonnes (Figure 10). It demonstrates that the actual yearly catches (about 450 tonnes on average 2003-2015) are significantly beyond the sustainable yield, in particular over the last 4 years (over 700 tonnes per year since 2014).

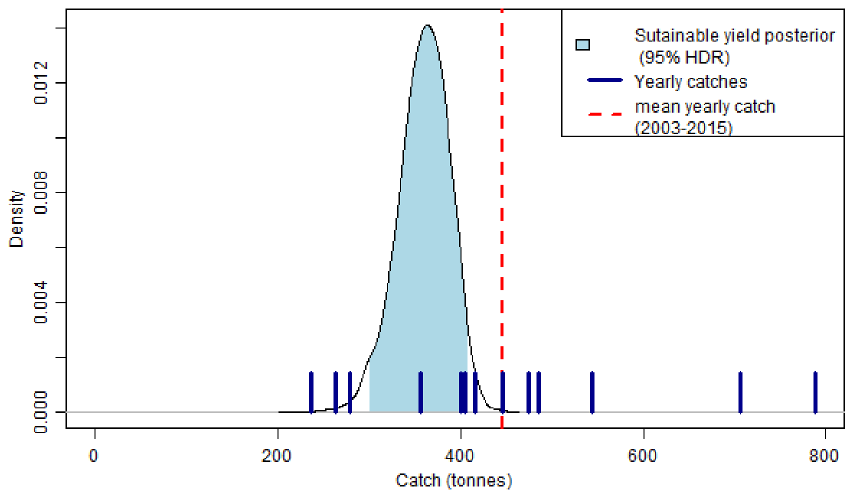

Figure 10. Estimated posterior distribution of the "optimistic" sustainable yearly yield. The actual yearly catches are also shown for comparison

5.5.5 Spawning Potential Ratio (SPR)

The size distributions of razor stocks change, becoming increasingly truncated at large sizes, as the rate of exploitation increases. Theoretically there is a size distribution and a rate of fishing that would result in sustained average maximum sustainable yield (MSY). The spawning and recruitment potential (represented here by the spawning potential ratio; SPR) for the stock is also affected by changes in the size distribution, given that maturity and selectivity are size related, and by overall abundance of different size classes. In Irish Sea fisheries there have been changes over time in size (and grade) composition. In the extreme case, representing an economically collapsed fishery in Rosslare Bay, the stock is dominated by small clams under the commercial size. Size distributions in the North Irish Sea in 2000 had higher proportions of larger clams than distributions in more recent years. To date, even in Rosslare, however, there is no evidence of declines in recruitment suggesting that relatively low spawning stock biomass can sustain recruitment or that these fished areas may be supplemented by recruitment from outside.

Time series of SPR for the Razor clam stock in the North Irish Sea shows a general declining trend and are well below the estimated optimum MSY reference point of 0.3 indicating that the stock has become increasingly overfished (Figure 11).

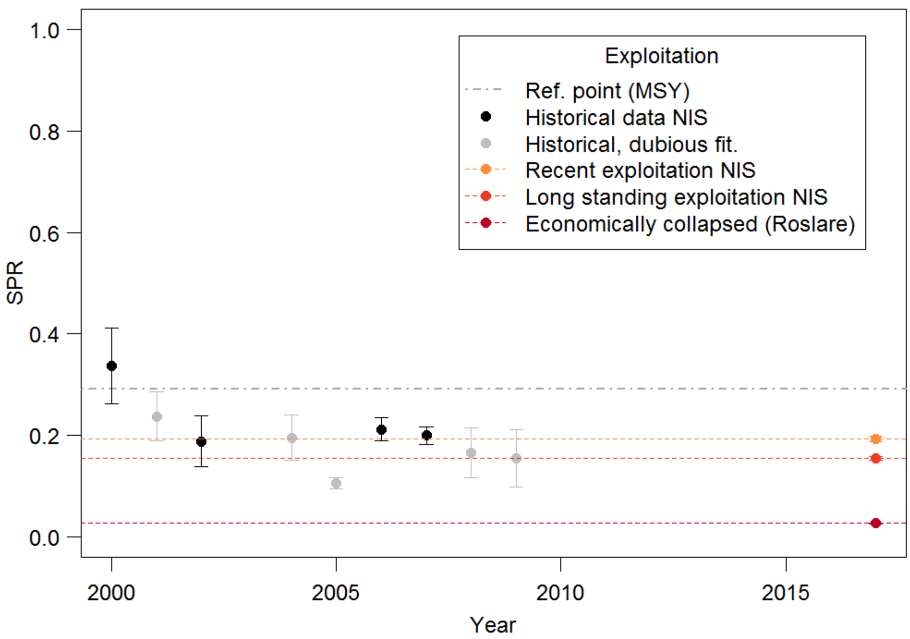

Figure 11. Spawning Potential Ratio (SPR) estimates for recently exploited areas, areas which have been fished for longer periods of time and for economically collapsed stocks relative to an SPR reference point of 0.3 (estimated assuming that 80% of maximum recruitment occurs at $0.2B_0$ where B_0 is the unexploited biomass)

5.5.6 Economic viability of the fishery

Prices of Razor clams per kilogram (Table 5.2) increased from an average of €2.21 in 2010 to €6.20 in 2016. Price is related to grade or shell length and varies from €3.50 for clams less than 160 mm shell length to €12.00 for clams over 200 mm shell length in 2018 (industry market data). The market incentivises fishing for medium and large grade clams. Given the individual weekly quota of 600 kgs per vessel this price structure may result in high grading at sea in order to maximise the value of the weekly quota. This also increases fishing costs and time at sea however and is only cost effective to a degree.

Other than labour costs diesel is the main operating cost. Other costs have not been estimated at this point and the cost:earnings ratio is not fully known. Daily fuel costs increased from 2010-2012 and declined from 2012-2016 (Table 5.2). Net value of clams caught per hr spent at sea increased from 2011-2015 and declined in 2016 and significantly in 2017.

Profitability declines with declining catch rates because fishing costs to take the weekly quota increases (Figure 12). In 2018 the net value of the quota, estimated from the size structure of the stock from the 2018 survey, market price data, 2017 catch rate data and allowing for certain costs and minimum wage payment to one member of crew, was approximately €2,000. The availability and catch rate of very large clams declined from 6% in 2017 to 2% in 2018. Large clams declined from 26% to 22%. This trend is expected to continue given the current fishing rate and will further erode the value of the quota because either the unit price will be lower or fishing costs will increase if operators high grade in an attempt to maintain unit price.

Table 5.2. Annual trends in fuel costs, hrs at sea, price of clams, LPUE and net (of fuel) value of the catch between 2010 and 2017

	Daily fuel cost	Diesel per Litre	Hrs at sea per day	Price of clams per kg	Kgs clams per dredge hr	Net value of daily landings	Net value per hr at sea
2010	€208	€0.65	13.2	€2.21	32.20	€599.00	
2011	€244	€0.80	17.1	€2.54	20.42	€638.00	€36.90
2012	€272	€0.92	14.2	€3.45	20.22	€669.00	€45.60
2013	€227	€0.88	14.7	€3.79	19.03	€702.00	€45.70
2014	€180	€0.79	12.9	€4.60	17.81	€908.00	€65.00
2015	€148	€0.73	12.6	€5.60	17.91	€1,185.00	€88.00
2016	€136	€0.60	13.4	€6.20	15.44	€1,077.00	€85.00
2017	€193	€0.62	15.9	€5.90	13.19	€1,027.00	€64.85

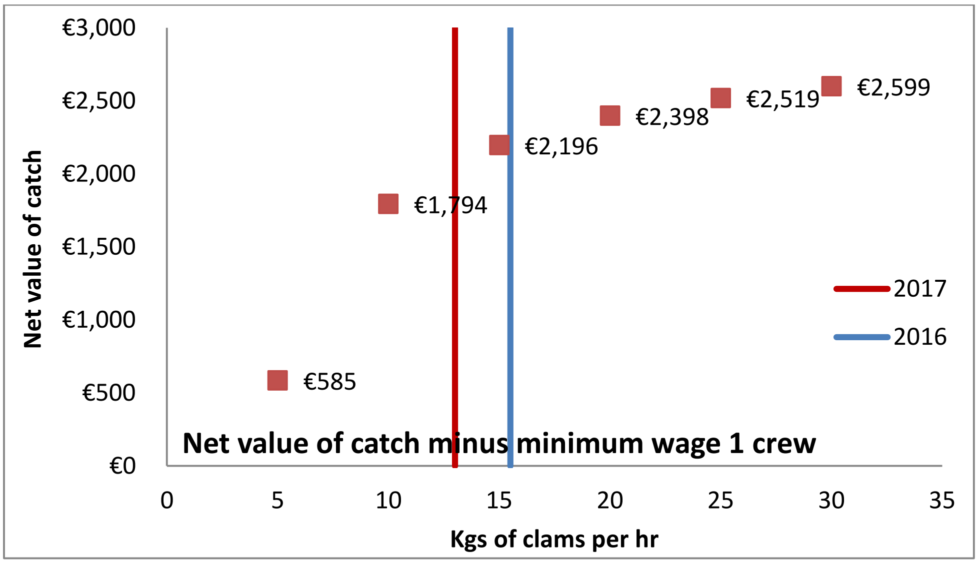

Figure 12. Net value of the weekly razor clam vessel quota of 600 kgs relative to catch rate per hour based on size / grade structure of the stock in the 2018 survey, payment of minimum wage to 1 crew and allowing for hourly fuel cost of €10.20 and other weekly operating costs of €233. The vertical lines indicate the catch rate per hour in 2016 and 2017.

5.6 South Irish Sea

5.6.1 Landings

The fishery opened in quarter 4 of 2010 and landings increased annually up to 2013 to over 350 tonnes (Figure 13). Landings declined annually from 2013 to 95 tonnes in 2018. The fishery occurs mainly in Rosslare Bay and further north at Curracloe. The Rosslare Bay fishery was closed by voluntary agreement in 2017 and 2018 due to decline in the availability of large clams. Approximately 12 vessels fish in the area but this number changes seasonally with some vessels moving to the north Irish Sea.

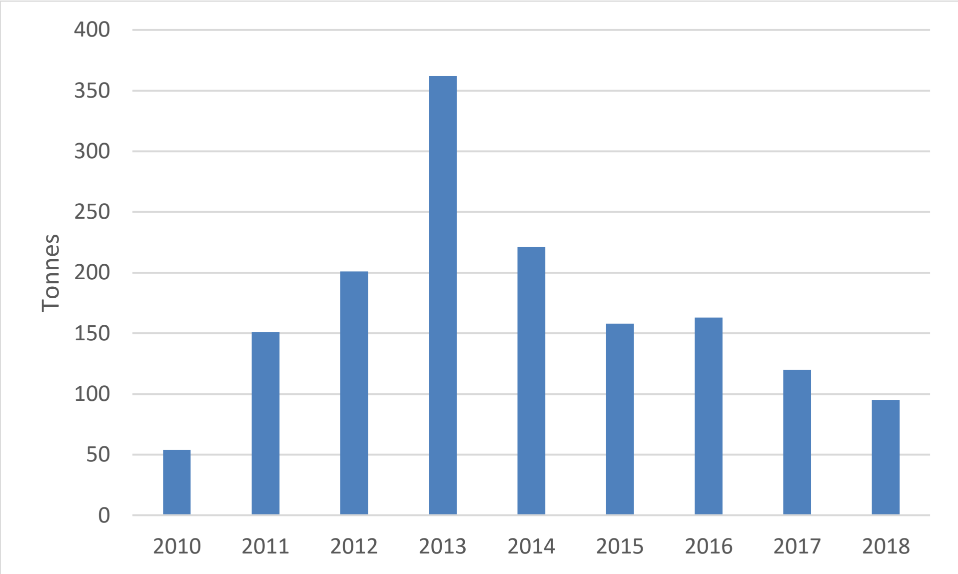

Figure 13. Annual landings estimated from a combination of logbook and gatherers data of razor clams in the south Irish Sea 2010-2018. The fishery opened in quarter 4 of 2010.

5.6.2 Survey 2018

A survey was completed during August 2018 (Figure 14). The eastern boundary of the survey extended beyond the eastern boundary of the classified production (fishery) area (CPA). The biomass of razor clams in the survey area of 10.5 km^2 was 4,174±975 tonnes. The biomass of clams over 130 mm in the survey area was 2,000 tonnes and the biomass over 150 mm was 443 tonnes. Biomass within the CPA was 3,866 tonnes (Table 5.3). This was 1,275 tonnes higher than in April 2017 for the same surveyed area. The biomass over 130 mm was 1,730 tonnes, which was 1,011 tonnes higher than in 2017 and biomass over 150 mm was 372 tonnes representing a decline of 134 tonnes compared to 2017.

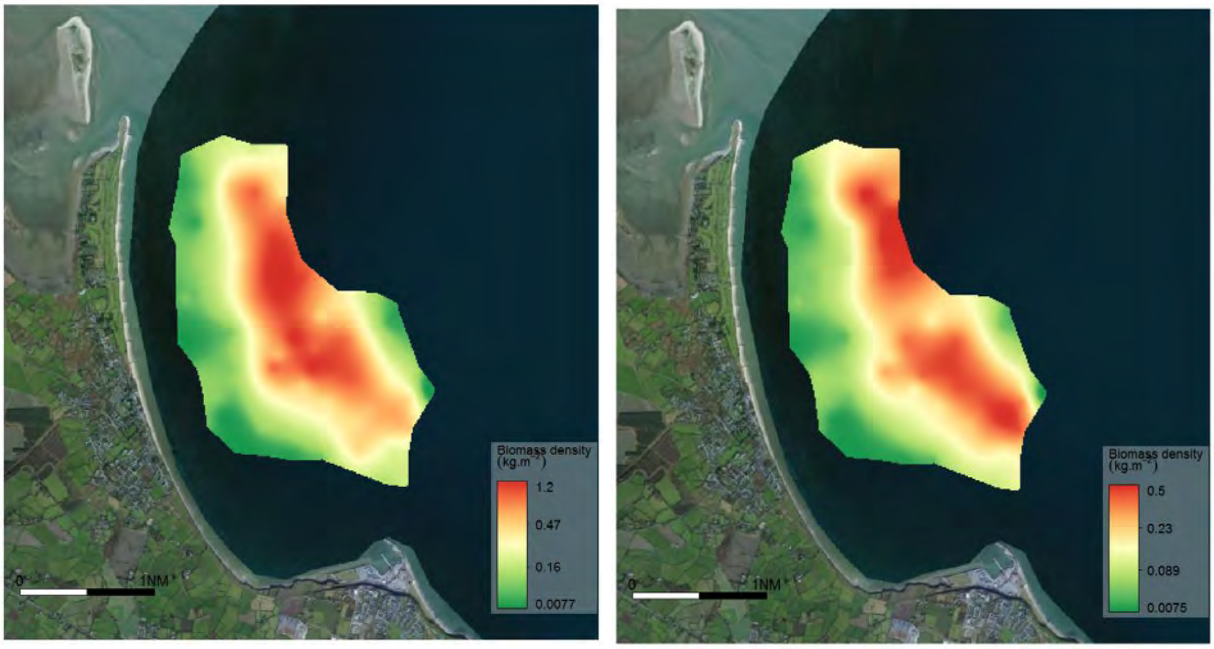

Figure 14. Distribution of biomass and density of razor clams in Rosslare Bay in August 2018. Total on left, clams over 130 mm on right.

Table 5.3. Biomass of razor clams (*Ensis siliqua*) in Rosslare Bay CPA in May 2017 and August 2018

	2017			2018			Difference
	Mean (tonnes)	95% CI		Mean (tonnes)	95% CI		
Total	2,590	2,169	3,119	3,866	3,348	4,378	1,275
Over **130** mm	718	587	824	**1,730**	1,509	1,967	1,011
Over **150** mm	506	429	597	372	337	413	-134

The size distribution of clams in April 2017 was dominated by, what is thought to be, a single age class of clams with a size mode of 108 mm (Figure 15). Based on estimated growth rates these clams were approximately 4 years old in 2017. The modal size in 2018 was 128 mm indicating an approximate annual growth of 20 mm shell length between age 4 and 5.

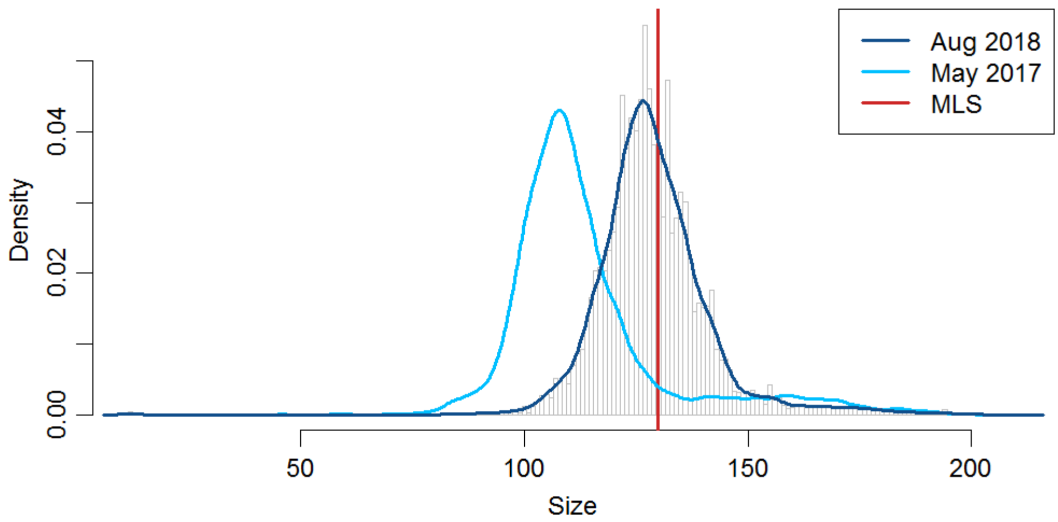

Figure 15. Size distribution of razor clams (*Ensis siliqua*) in Rosslare Bay in May 2017 and August 2018. The minimum landings size (130 mm) is shown.

5.6.3 Catch advice

Advice on catch options for razor clams nationally has been based on a HR of 10-15%. This would enable a catch of 387-580 tonnes from Autumn of 2018 to Autumn 2019 for Rosslare Bay. This is higher than previous annual landings from Rosslare and Curracloe beds combined which peaked in 2014 at approximately 400 tonnes. The commercial value of the catch at €3.50 per kg would be between €1.35 and €2.03million given that almost all the clams, especially in the production area, would still be less than 160 mm in 2019. Information on growth rates to project the expected size distribution into 2019 shows a further increase in size with a predicted mode at 140 mm (compared to 128 mm in 2018). Over 52% of clams would be over 140 mm in mid-2019 compared to just 15% in August 2018 (Figure 16). The proportion over 160 mm would be 3.5% in 2019 compared to 0.5% in 2018.

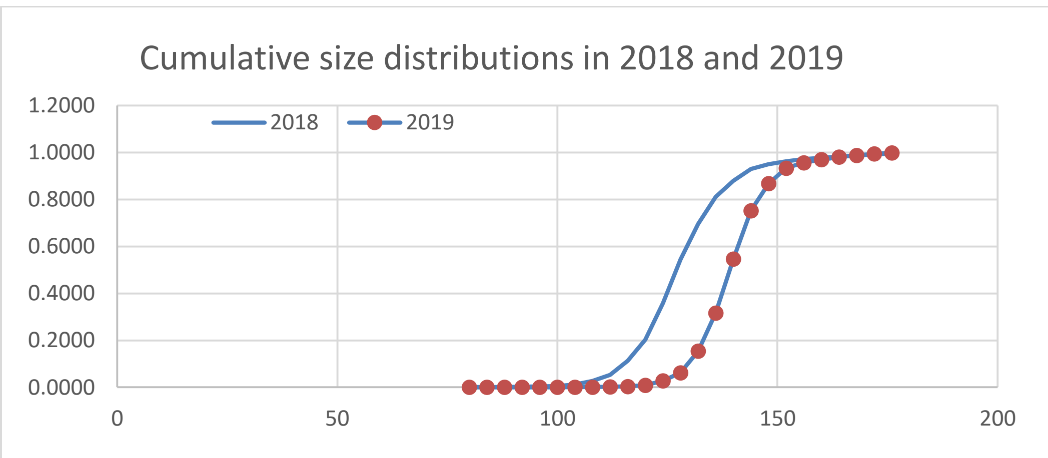

Figure 16. Size distribution of razor clams (*Ensis siliqua*) in Rosslare Bay in August 2018 and projected based on growth rate estimates to mid 2019.

5.7 Waterford Estuary

A survey of razor clams in Waterford estuary was completed in November 2017. The razor clam stock is distributed in two areas in Harrylock Bay and on the west side of the estuary at Creadon Head. The clam bed is distributed over an area of at least 4.2 km^2 (Figure 17).

The total biomass of razor clams in the estuary was 269 tonnes. Approximately 216 tonnes were over 130 mm and practically all the biomass was over the legal landing size of 100 mm (Table 5.4). The size distribution was skewed towards larger size classes (Figure 18) typical of unexploited razor stocks and in contrast to previously heavily fished stocks such as Rosslare Bay (see section 5.6.2)

Catch advice for 2018 and as agreed by the management planning process was 40 tonnes.

Table 5.4. Estimates of biomass of razor clams in Waterford estuary in November 2017

	Biomass (tonnes)		95% confidence intervals	
	mean	**median**	**Lower**	**Upper**
Biomass all sizes	269.2	268.8	231.5	309.1
Biomass >130 mm	216.8	216.6	193.6	241.5

Figure 17. Distribution of razor clams (*Ensis siliqua*) in Waterford estuary in November 2017.

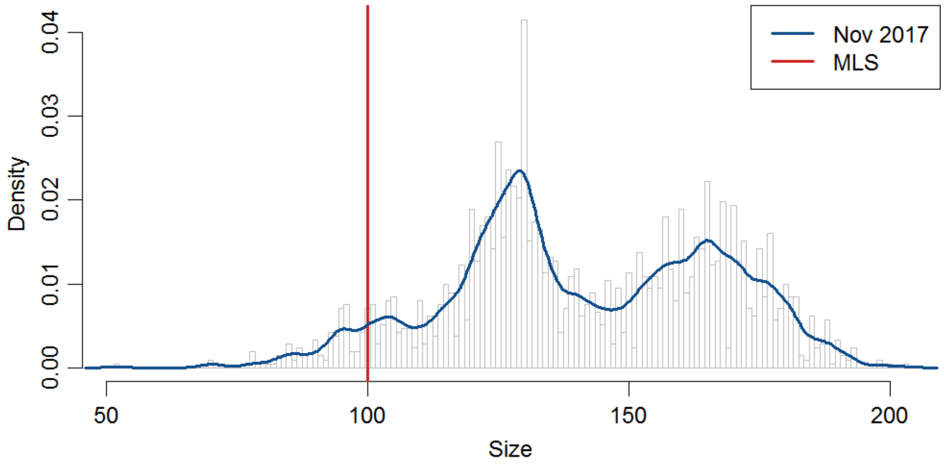

Figure 18. Size distribution of razor clams (*Ensis siliqua*) in Waterford estuary in November 2017.

5.8 Inisbofin

An area south west of Inisbofin was surveyed on Aug 22nd 2018. *E. magnus* is the main species in this area with small numbers of *E. siliqua* (too low to estimate biomass). Nineteen stations were surveyed over an area of 0.34km^2 (Figure 19).

The biomass was 105 tonnes almost all of which was over the minimum landing size (Figure 20, Table 5.5).

No fishery occurred in 2018 and no catch advice or management plan was developed.

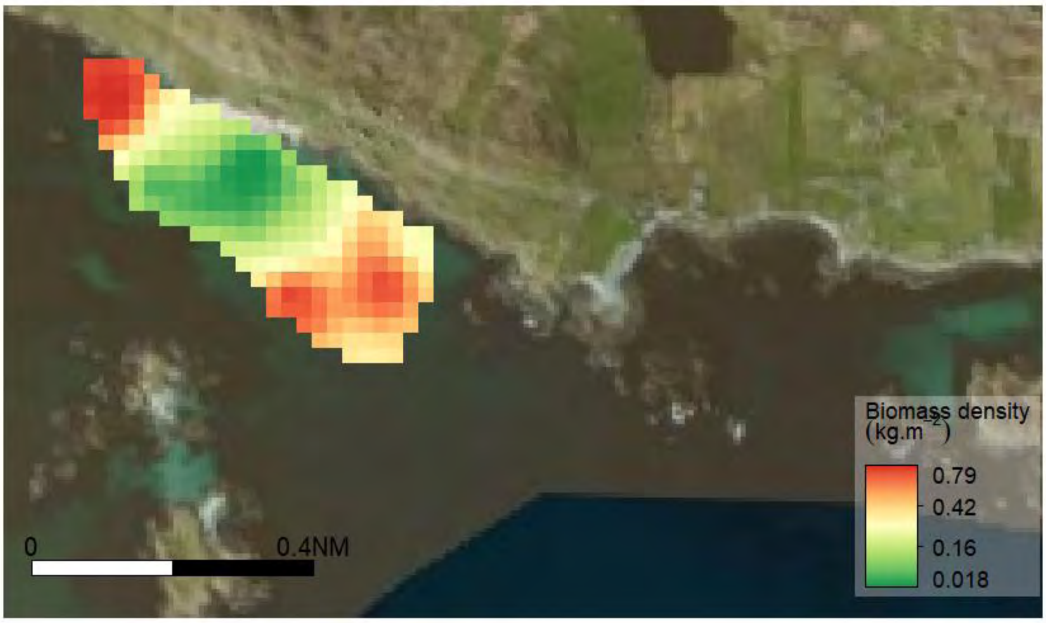

Figure 19. Distribution of razor clams (*Ensis magnus*) south of Inisbofin in August 2018.

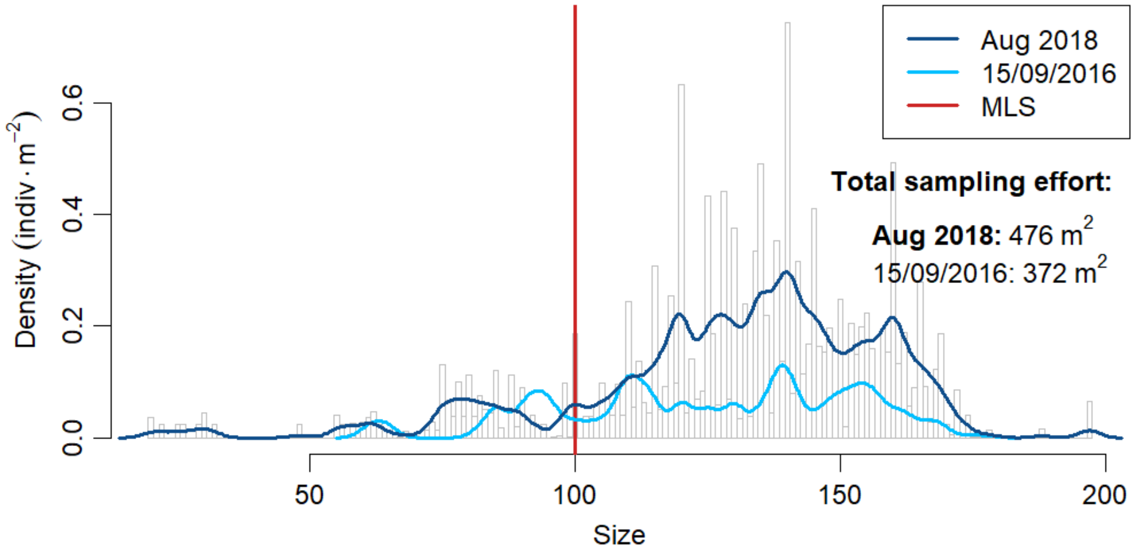

Figure 20. Size distribution of razor clams (*Ensis magnus*) south of Inisbofin in Aug 2018 and Sept 2016.

Table 5.5. Estimates of biomass of razor clams south of Inisbofin in August 2018.

	Mean Biomass	95%CL Lower	95%CL Upper
E. magnus	104.9	79.6	146.5
***E. magnus* >100mm**	102.0	79.0	144.4

5.9 Killary Harbour

The approaches to Killary Harbour were surveyed on August 13th 2018. Fifteen stations were sampled in shallow water. Deeper areas could not be accessed during the survey so 2018 and 2016 data were combined to provide a biomass estimate for the stock area. No fishery has occurred in the area recently. The stock is distributed over an area of 0.97km^2 although density is much lower in the deeper part of the area.

E. siliqua and *E. magnus* occur in the area in commercial quantities. *E. ensis* was recorded in low numbers (Figure 21, Figure 22).

Estimated biomass of *E. magnus* and *E. siliqua* was 24 tonnes and 71 tonnes respectively. No confidence intervals are available due to difficulty in estimation caused by poor survey coverage in deep water. Almost all of this biomass was over the minimum landing size (Figure 23, Figure 24).

No fishery occurred in 2018 and no catch advice or management plan was developed.

Table 5.6. Estimates of biomass of razor clams at the Killary approaches (2016-2018)

Species	Biomass (tonnes)
Ensis_magnus	24.1
Ensis_siliqua	70.9
***Ensis_magnus* >100mm**	23.9
***Ensis_siliqua* >130mm**	66.9

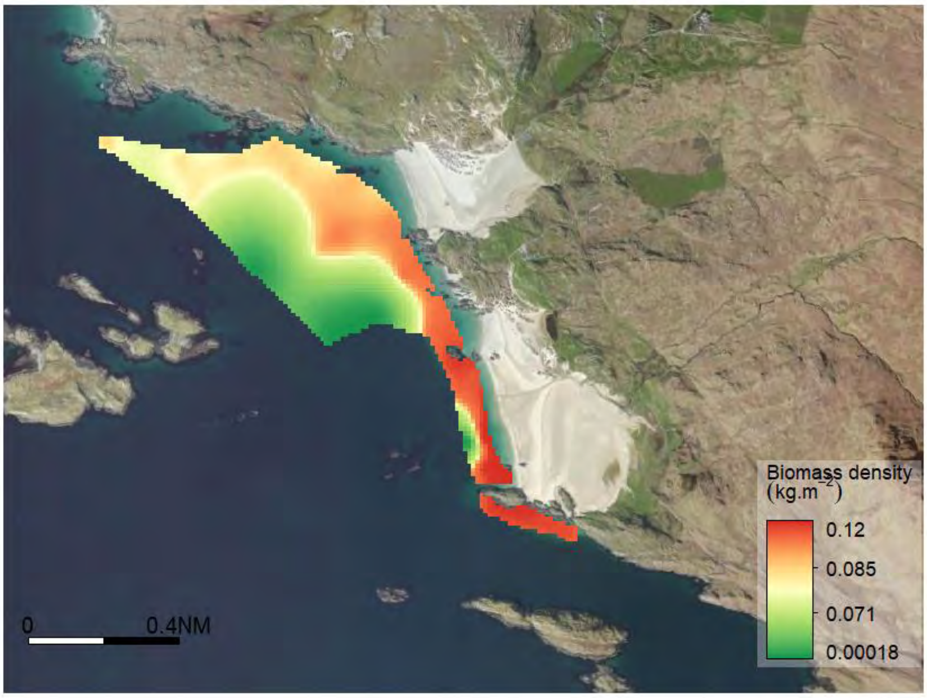

Figure 21. Distribution of razor clams (*Ensis siliqua*) at the approaches to Killary Harbour in August 2018.

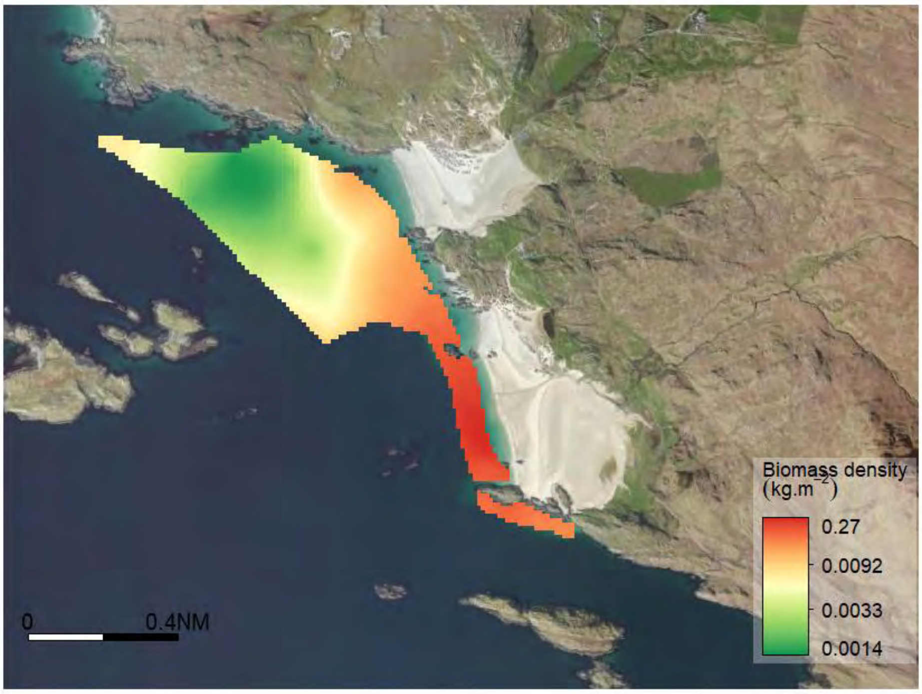

Figure 22. Distribution of razor clams (*Ensis magnus*) at the approaches to Killary Harbour in August 2018.

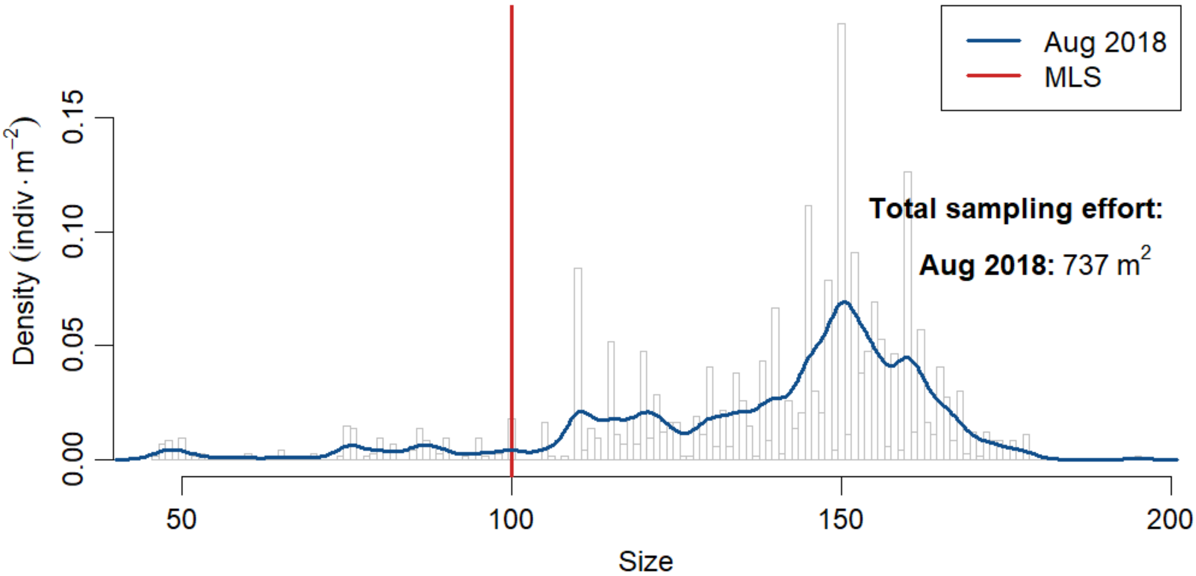

Figure 23. Size distribution of razor clams (*Ensis magnus*) at the Killary approaches in August 2018.

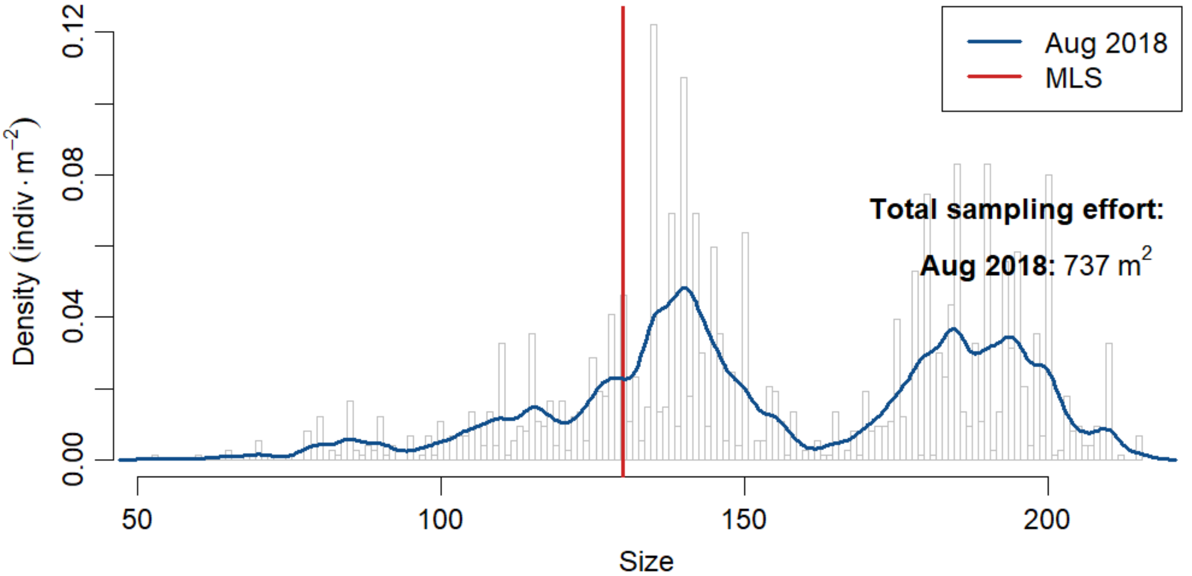

Figure 24. Size distribution of razor clams (*Ensis siliqua*) at the Killary approaches in August 2018.

5.10 Ballinakill Bay

Ballinakill Bay was surveyed for razor clams in April 2018. The most abundant species present was *Ensis magnus* with lower densities of *E. siliqua*. The area surveyed was 0.48 km^2. No fishery has recently occurred in the area.

The total biomass of *Ensis magnus* in the Bay in April 2018 was 85 tonnes. Approximately 84 tonnes was over 100 mm in shell length (Figure 25, Table 5.7). This estimate is lower than the 111 tonnes estimated in 2016 over a smaller area and much lower than the biomass extrapolated to the area of potential habitat available from the 2016 survey. The size distributions are similar in both surveys. The 2018 estimate is more precise than that of 2016 although in both cases the estimates are uncertain. This is largely due to the way the stock is distributed along a narrow strip of sand along the north shore in particular making interpolation and estimation difficult. The biomass of *Ensis siliqua* was 5 tonnes.

The size distribution was skewed towards larger size classes typical of unexploited razor clam stocks (Figure 26).

Catch advice for 2018, was 15% of biomass or 13 tonnes for *E. magnus* and 1 tonne for *E. siliqua*.

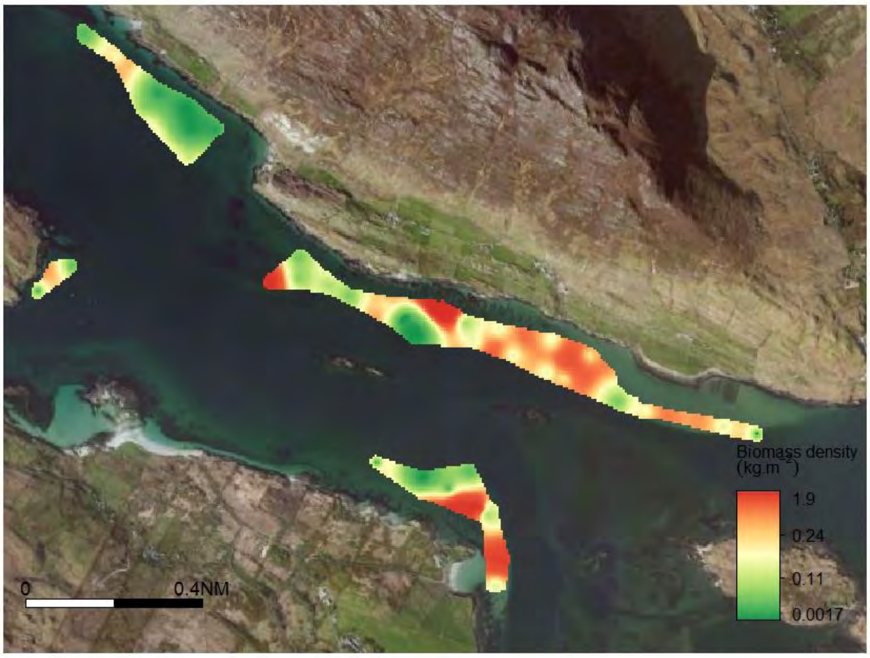

Figure 25. Distribution of razor clams in Ballinakill Bay in April 2018.

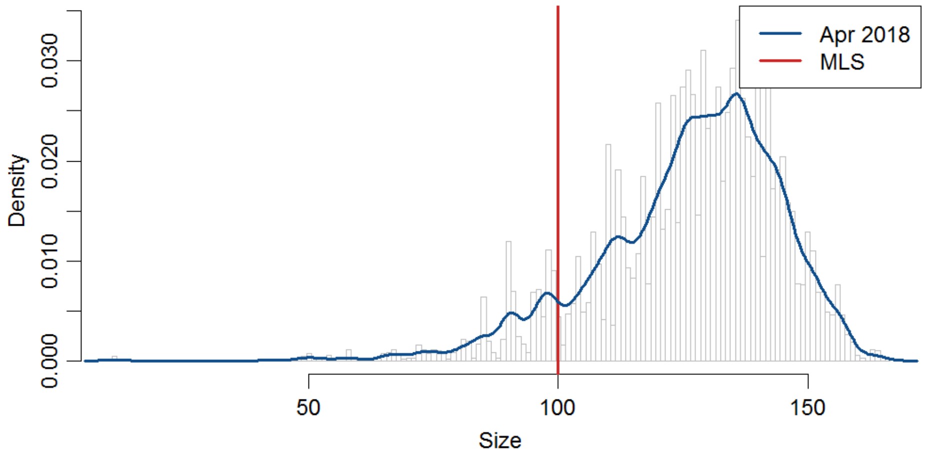

Figure 26. Size distribution of razor clams (*Ensis magnus*) in Ballinakill Bay in April 2018.

Table 5.7. Estimates of biomass of razor clams in Ballinakill Bay in April 2018

	Biomass (tonnes)		**95% confidence intervals**	
	mean	**median**	**Lower**	**Upper**
Ensis magnus				
Biomass all sizes	85	84	56	309.1
Biomass >10**0 mm**	84	83	49	241.5
Ensis siliqua				
Biomass all sizes	5	4.8	3	8

6 Cockle (*Cerastoderma edule*)

6.1 Management advice

The Dundalk Bay cockle fishery is managed under a Natura 2000 site fisheries management plan and declaration. The stock is assessed by annual survey and in season LPUE data. Trends in other ecosystem indicators (benthic habitats, bird populations) are integrated into management advice. TAC is 33% of total biomass on condition that ecosystem indicators for designated habitats and bird populations are stable.

Maintenance of good environmental status in the intertidal habitats in which these fisheries occur is a primary management objective in order to reduce the risk of future recruitment failure and to ensure that conservation objectives for designated habitats and species are protected. Any cockle fisheries in SACs or SPAs in other areas should be subject to management plans considering their potential effects on designated habitats and birds.

Pre-fishery summer surveys in Dundalk Bay 2018 showed strong recruitment and good over wintering survival of cockles. Biomass in 2018 was 1785 tonnes. The TAC for 2018 was 542 tonnes. Landings were 446 tonnes.

The harvest control rules which have been in place since 2007 should be continued but the limit reference biomass at which a fishery takes place should be increased from 850 tonnes to 1,500 tonnes or harvest rates between 850 and 1,500 tonnes should be reduced.

6.2 Issues relevant to the assessment of the cockle fishery

There are a number of cockle beds around the Irish coast, however in recent years the main fishery has occurred in Dundalk Bay.

Recruitment of cockles in Dundalk Bay occurs regularly but overwinter survival, in particular, is highly variable. As a consequence biomass, in some years, is insufficient to support a fishery. Recruitment failures occur frequently in the Waterford estuary and overwinter survival is also generally low. In most areas growth rates are lower than in Dundalk and cockles need to survive over 2 winters to reach commercial size compared to 1 winter in Dundalk.

Annual surveys, provided they are completed close to the prospective opening date for the fishery, provide good estimates of biomass available to the fishery and the prospective catch rates. Growth and mortality result in significant changes in biomass over short periods of time.

Dundalk Bay is under a Natura 2000 site management regime and a fishery natura plan for cockles. Cockle is both a characterising species of designated habitats within these sites and also an important food source for overwintering birds. Management of cockle fisheries takes into account the conservation objectives for these habitat and species.

Continuing commercial fisheries for cockles in Natura 2000 sites will depend on favourable conservation status of designated environmental features that may be affected by this fishing activity or a clear demonstration that changes to designated features are not due to cockle fishing.

6.3 Management Units

Cockle stocks occur in intertidal sand and mud habitats. These habitats occur as isolated and discrete areas around the coast and as a consequence cockle stocks occur as locally self-recruiting populations.

Although there are many cockle populations around the coast only Dundalk Bay has supported commercial dredge fisheries in recent years. There is a small scale commercial hand gathering fishery in Castlemaine Harbour (Kerry). Commercial stocks also occur in Tramore Bay and Woodstown Co. Waterford and in Clew Bay Co. Mayo but these stocks have not been commercially fished in recent years. In addition cockle stocks occur in Mayo (other than Clew Bay), Kerry, Sligo and Donegal in particular but these have not been surveyed and are not commercially fished.

6.4 Management measures

The management measures for the Dundalk fishery are described in 5 year management plans (2011-2016 and 2016-2020) and specified in annual legislation in the form of Natura Declarations (www.fishingnet.ie).

In Dundalk Bay a cockle permit is required to fish for cockles either by vessel or by hand gathering. The number of vessel permits is limited to 32. The permit is transferable.

Annual TAC is set at 33% of biomass estimated from a mid-summer survey. The fishery closes if the average catch per boat per day declines to 250 kg even if the TAC is not taken. This provides additional precaution given uncertainty in the survey estimates. Opening and closing dates are specified annually. The latest closing date of November 1st is implemented even if the TAC has not been taken or if the catch rate remains above the limit for closure. Vessels can fish between the hours of 06:00 and 22:00. Maximum landing per vessel per day is 1 tonne. Dredge width should not exceed 0.75 m in the case of suction dredges and 1.0 m for non-suction dredges. The minimum legal landing size is 17 mm but operationally and by agreement of the licence holders the minimum size landed is 22 mm. This is implemented by using 22 mm bar spacing on drum graders on board the vessels.

Environmental performance indicators are reviewed annually as part of the management plans and the prospect of an annual fishery depends on annual evidence that there is no causal link between cockle fishing and in particular the abundance of oyster catcher and other species of bird that feed on bivalves and the status of characterising bivalve species in intertidal habitats.

6.5 Dundalk Bay

6.5.1 Biomass and landings 2007- 2018

Biomass estimates from annual surveys in 2007-2018 are not strictly comparable because of differences in the time of year in which surveys were undertaken (Table 6.1). The annual estimates are highly sensitive to the timing of in year settlement and seasonal mortality of established cohorts relative to the time in which the surveys are undertaken. The March 2007 survey for instance would not have detected settlement that occurred in 2007. Nevertheless since 2009 surveys have been undertaken either in May or June.

Biomass has varied from a low of 814 tonnes in 2010 to 3,588 tonnes in 2008. Biomass increased annually between 2014 and 2017 from 972 tonnes to 2,316 tonnes. TAC is based on an advisory

33% exploitation rate provided that the survey biomass is over 850 tonnes. In effect however no fishery has occurred when the biomass was less than 1,032 tonnes (2015). When the fishery is opened the TAC uptake has varied from 15% (2009) to 100% (2017 and 2018). This depends on distribution of biomass and the commercial viability of fishing and market prices.

Table 6.1. Annual biomass, TAC and landings of cockles in Dundalk Bay 2007-2017

Year	Survey Month	Biomass		TAC (tonnes)	Landings	
		Mean	95% CL		Vessels	Hand gatherers
2007	March	2,277	172	950	668	Unknown
2008	August	3,588	1,905	0	0	0
2009	June	2,158	721	719	108	0.28
2010	May	814	314	0	0	0
2011	May	1,531	94	510	325	0.25
2012	May	1,234	87	400	394	9.4
2013	June	1,260	99	416	343	0
2014	June	972	188	0	0	0
2015	June	1,032	100	0	0	0
2016	July	1,878	87	626	410	0
2017	June	2,316	95	772	775	0
2018	June	1,785	175	542	446	0

6.5.2 Survey in 2018

6.5.2.1 Biomass

A pre-fishery survey was completed in June 2018. The survey area was 29.6 km^2. Total biomass was 1,785 tonnes (Table 6.2, Figure 33). Biomass of cockles over 22 mm was 1,378 tonnes.

Based on the management plan which specifies a harvest rate of 0.33 and the biomass estimate a TAC of 542 tonnes was advised. This was based on a more conservative estimate of biomass in July 2018 using a Bayesian model and which was subsequently re-worked using geostatistical methods to give the higher estimate of 1,785 tonnes reported here.

Table 6.2. Biomass of cockles in Dundalk Bay in June 2018

	Biomass (tonnes)		95% HDI inf
	mean	median	
Biomass (tonnes)	1,785	1,789	1,610
Biomass (tonnes) > 22mm	1,378	1,379	1,250
Biomass (tonnes) < 18mm	1,208	1,205	1,098
Biomass (tonnes) > 18mm	367	370	325

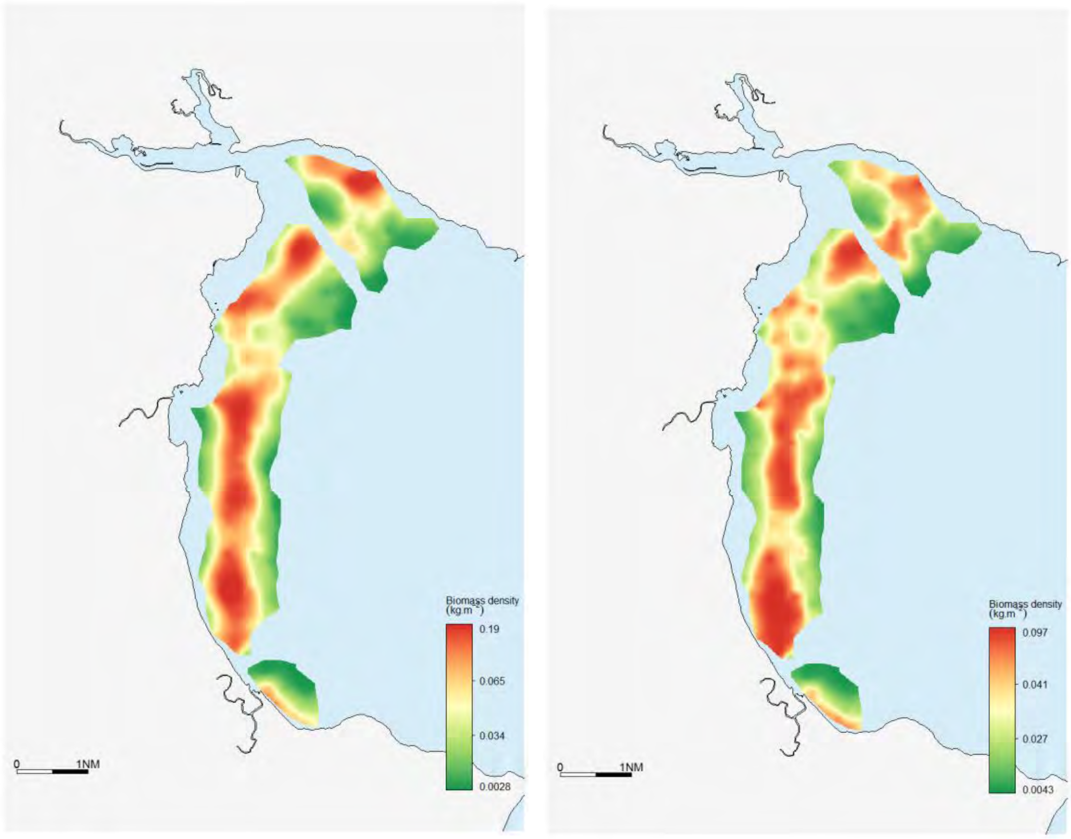

Figure 27. Distribution and density (kgs.m^{-2}) of all cockles (left) and commercial cockles (>22mm shell width) in Dundalk Bay in June 2018

6.5.2.2 Size distribution and recruitment

The size distribution was clearly bi-modal. Cockles aged 0+ were strongly represented in June 2018 (Figure 28) signalling a strong settlement event in Spring 2018. Over 69% of cockles in the survey were 0+, 12% were 1+ and 11% were 2+. There was a seven fold increase in weight between age 0+ and 1+ and a 12 fold increase in weight between 0+ and 2+.

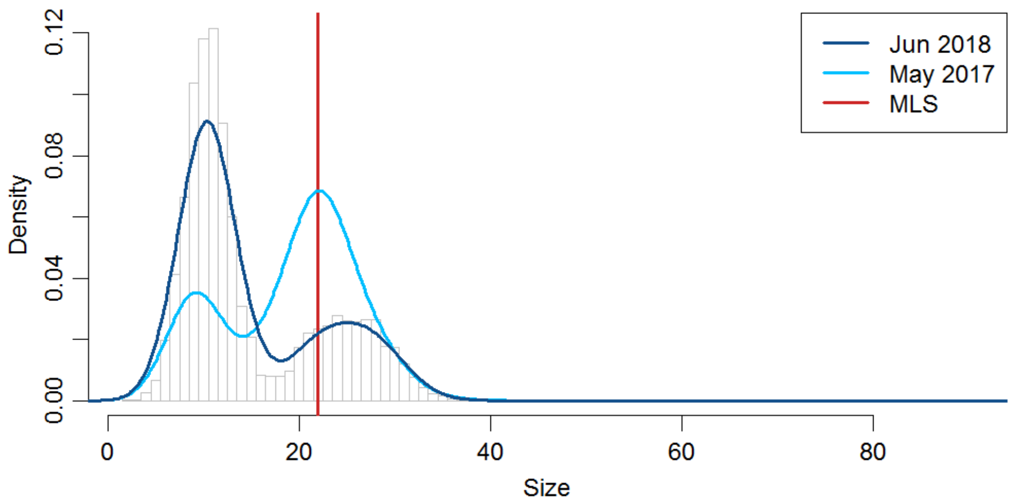

Figure 28. Size distribution of cockles in Dundalk Bay in June 2018.

6.5.2.3 Fisheries monitoring and exploitation rate

Total landings of cockle from Dundalk Bay in 2018 was 446 tonnes (source: SFPA) from a TAC of 542 tonnes representing 82% uptake of quota. The fishery opened on July 23rd and the final landings were made on Oct 26th. None of the conditions to close the fishery were reached at that point.

Catch rates ranged from approximately 600 kgs per vessel per day in July to just under 400 kgs per day in October when the fishery closed (Figure 29) indicating, as per the management plan harvest control rule, a HR of 33% of biomass. Biomass estimated from the depletion of catch rate (i.e. the landings if cpue was extrapolated to zero) was 1,050 tonnes which was significantly less than the survey estimate of 1,785 tonnes. However, the entire stock is not exposed to fishing due to tidal restrictions on where the vessels can operate.

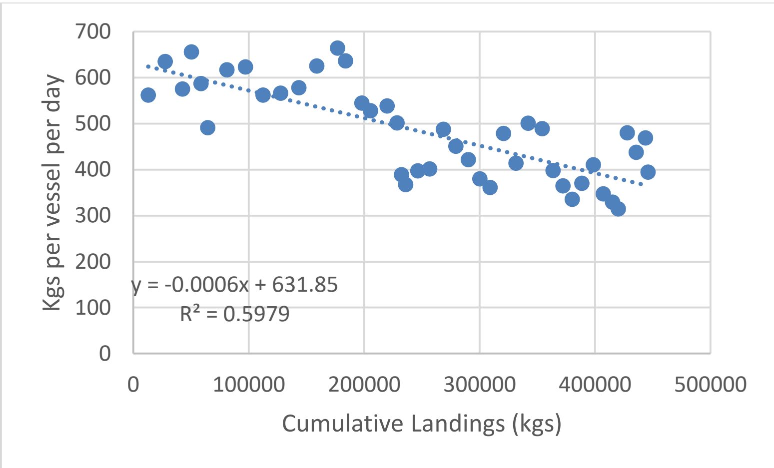

Figure 29. Changes in catch rates in relation to cumulative landings during the Dundalk cockle fishery in 2018. Source: SFPA gatherers data.

7 Oyster (*Ostrea edulis*)

7.1 Management advice

Oyster stocks are assessed by annual surveys which provide biomass estimates although dredge efficiency (catchability) is uncertain.

Stock biomass is generally low in all areas, except inner Tralee Bay, and management measures to restore recruitment and re-build spawning stocks are necessary. Various threats to native oyster stocks exist including naturalisation of Pacific oyster (*Magallana gigas*), *Bonamia* infection, poor water quality and unfavourable habitat conditions for settlement and low spawning stocks.

Pacific oyster has naturalised in Lough Swilly in recent years and has in some years supported a commercial fishery.

Generally, although seasonal quotas and minimum size regulations are in place for some fisheries, management plans or recovery plans should be developed in order to restore productivity to stocks. This should include a range of actions including removal of Pacific oysters, maintenance or recovery of habitat including cultching, closure of fisheries where only a small proportion of oysters are over the minimum size and to allow for growth and use of various aquaculture based stock enhancement measures.

Oyster beds are also constituents of habitats designated under the Habitats Directive in many areas. Specific conservation objectives have been defined for these habitats in some sites. Oyster management plans also need to consider the conservation objectives for oyster habitat or for habitat in which oyster is a characterising species.

7.2 Issues relevant to the assessment of the oyster fishery

A number of native oyster beds occur as separate stocks in Bays around the coast. Biomass is currently low, compared to historic levels, in most areas. The Inner Tralee bed holds the majority of the national biomass of native oyster.

Recruitment is variable in most areas although settlement occurred in all areas recently surveyed. Larval production and settlement is conditional on density of spawning stock, high summer temperatures and the availability of suitable settlement substrate.

The fishery is managed primarily by a minimum landing size (MLS) of 76-78 mm. The minimum size is generally reached at age 4-5. Oysters generally mature well below the MLS.

Oyster stocks face a number of threats including *Bonamia* infection, which decimated stocks in the 1970s, and is prevalent in a number of beds today and in 2017 was detected in the previously *Bonamia* free Kilkieran Bay. Native oyster is also competing for habitat with naturalised Pacific oyster in some areas such as Lough Swilly. Poor substrate conditions for settling oysters may be limiting recruitment and low stock density may also be reducing reproductive output.

Management authority has been devolved to local co-operatives through fishery orders issued in the late 1950s and early 1960s or through 10 year Aquaculture licences. Although conditions, such as maintaining oyster beds in good condition or having management plans in place, attach to these devolved arrangements in most cases management objectives and management measures are not sufficiently developed. In Lough Swilly and the public bed in inner Galway Bay all management authority rests with the overseeing government department rather than with local co-operatives.

Although management may be devolved through the fishery orders or aquaculture licences vessels fishing for oysters must be registered on the sea fishing vessel register (DAFM) and operators must also hold a dredge licence which is issued by Inland Fisheries Ireland (IFI).

The oyster co-operatives operate seasonal fisheries and may also limit the total catch. The TACs may be arbitrary and scientific advice or survey biomass estimates or other indicators have not generally been used in setting TACs.

All the main oyster beds in Ireland occur within Natura 2000 sites. Oyster is a characterising species of sedimentary habitats of large shallow inlets and bays. It can also be a key habitat forming species in conditions where recruitment rates are high and where physical disturbance is low. Seagrass and maerl or other sensitive reef communities are commonly found on oyster beds in Kilkieran Bay, Tralee Bay, Clew Bay (outer). Dredging may damage these communities. Management of oyster fisheries needs to consider the conservation objectives for this species and its associated habitats and communities.

Annual surveys provide biomass indices or absolute biomass estimates and size structure of oyster stocks annually. Poor information on growth rate, which varies across stocks, limits the assessment of mortality rates and yield predictions.

These issues were discussed at the Native Oyster Workshop in October 2017 hosted by Cuan Beo in Clarinbridge (www.cuanbeo.com). A new forum, the Irish Native Oyster Fisheries Forum (INOFF) was established in 2018 representing all oyster co-ops to discuss site specific issues and future management and restoration of oyster stocks.

7.3 Management Units

Oyster stocks occur as discrete isolated units in a number of Bays around the coast. Although native oysters were historically widespread in many areas, including offshore sand banks in the Irish Sea and along the south east coast their distribution is now reduced. The main stocks occur in inner Tralee Bay, Galway Bay, Kilkieran Bay in Connemara, Clew Bay, Blacksod Bay and Lough Swilly.

7.4 Survey methods

Oyster beds are surveyed annually by dredge. Dredge designs vary locally and those locally preferred dredges are used in the surveys. Dredge efficiencies were estimated in 2010 by comparison of the numbers of oysters caught in the dredge and the numbers subsequently counted on the same dredge track by divers immediately after the dredge tow had been completed.

Surveys are undertaken along predetermined grids where the distribution of the oyster beds is well known. In other cases the local knowledge of the Skipper of the survey vessel is used to locate the beds which, in some areas, are patchy and occur at discrete depths on particular substrates. GPS units with visual display of the local area were used to distribute sampling effort throughout the oyster beds, the boundaries of which were indicated by the skipper of the vessel.

Densities, either converted for dredge efficiency or in raw form, were interpolated using an Inverse Distance Weighting (IDW) algorithm. Contours were drawn at intervals reflecting the range in observed densities. The geographic area inside each contour was calculated and used to raise the average densities and biomass of oysters m^{-2} within each contour to the total population or at least that proportion of the population selected by the dredge.

7.5 *Inner Tralee Bay*

7.5.1 Stock trends

Biomass estimates, standardised to a dredge efficiency of 35% varied from a low of 409 tonnes in 2015 to a high of over 1,000 tonnes in 2014 and 2018. The 2014 survey estimate is an outlier in the time series. The area surveyed usually contains the entire stock which is distributed over approximately 4 km^2 (Table 7.1).

Table 7.1. Stocks biomass trends for native oyster in Inner Tralee Bay 2010-2018

Year	Month of survey	Survey Area (km^2)	Biomass km^{-2}	Biomass
2010	September	4.26	230.54	982
2011	September	3.57	87.03	631
2012	February	3.8	85.02	655
2013	September	3.76	66.33	506
2014	September	3.8	164.16	1265
2015	September	4.51	44.78	409
2016	September	3.66	121.44	901
2017	September	4.28	197.08	843
2018	September	3.92	296.17	1161

7.5.2 Biomass and landings in 2018

A pre fishery survey was completed on September 26th and 27th 2018 on the inner Tralee Bay Oyster Bed. A total of 86 tows were undertaken, with a single toothless dredge of width 1.20m. GPS data for each tow line was recorded on a Trimble GPS survey unit and swept area for each tow was estimated. The survey encompassed an area of 3.92 km^2 east of Fenit pier (Figure 30).

Biomass of oysters uncorrected for dredge efficiency varied from 0-1 kgs.m^{-2} (Figure 30). Biomass of oysters over 78 mm ranged from 0-0.1kgs.m^{-2} (Figure 31).

Total biomass of oysters, assuming a dredge efficiency of 35%, was 1,161 tonnes (Table 7.2). The equivalent biomass of oysters 78 m or over was 199 tonnes, close to the estimate of 190 tonnes for 2017 (re-calculated using a similar model).

Table 7.2. Distribution of oyster biomass, corrected for a dredge efficiency of 35%, in Inner Tralee Bay in September 2018

	Biomass (tonnes)		95% confidence intervals	
Uncorrected for efficiency	**mean**	**median**	**Lower**	**Upper**
Biomass_***Ostrea_edulis***	405	405	309	496
Biomass_>78mm_***Ostrea edulis***	69.6	69.4	55.1	85.5
Corrected 35% Dredge Efficiency				
Biomass_***Ostrea_edulis***	1,161	1,159	897	1,419
Biomass_78_Inf_***Ostrea edulis***	199	198	155	250

Figure 30. Density and distribution of native oyster in Inner Tralee Bay, September 2018.

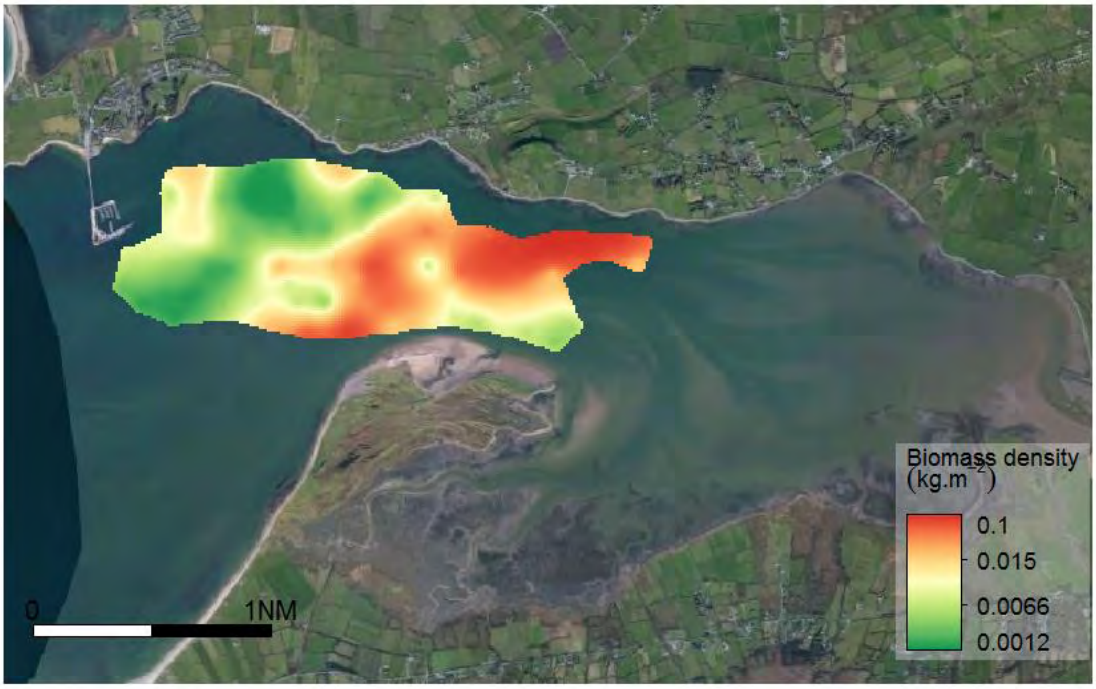

Figure 31. Density and distribution of commercial sized native oyster in Inner Tralee Bay, September 2018.

7.5.3 Size distribution 2018

The size distribution of oysters caught during the survey showed a strong mode at about 70 mm and a smaller mode at 20-40 mm (Figure 32). The location of the mode at 70 mm is similar to that in 2017. The similar or even slight left shift in the mode position suggests that mortality, associated with fishing, may occur from 70 mm rather than a 'knife edge' selection at 78 mm. The substantially highest density recorded for this main mode in 2018, compared to the one recorded in 2017, suggests a possible difference of dredging efficiency between years. Inter-annual variability in the biomass estimates must therefore be interpreted with caution. This might however also partially ensue from differences in the spatial distribution of the sampling effort (*e.g.* less sampling in 2018 in the south east corner of the survey area where low densities occur).

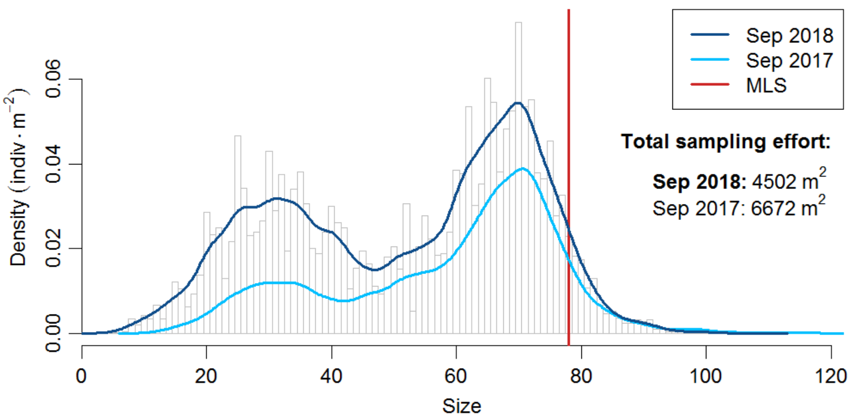

Figure 32. Size distribution of native oysters in the Fenit oyster bed in September 2018. The MLS (78 mm) is also shown.

7.6 *Lough Swilly*

A survey of native and Pacific oysters, involving 127 stations, was completed in Lough Swilly in April 2018

7.6.1 Native oyster

7.6.1.1 Stock trends

The area covered by the surveys has varied significantly during the time series which compromises inter year comparisons. Generally biomass, corrected for dredge efficiency of 35%, is between 15-44 tonnes.km^{-2}. Biomass.km^{-2} was higher in 2017 and 2018 than previous years.

Table 7.3. Stocks biomass trends for native oyster at Lough Swilly 2011-2018

Year	Month	Survey Area (km^2)	Biomass km^{-2}	Biomass
2011	March	1.56	25.64	40
2011	November	13.07	9.52	124
2012	October	11.48	15.46	177
2013	October	5.96	14.14	84
2014	October	13.19	15.85	209
2015	August	5.19	6.50	33
2016	August	5.58	17.40	97
2017	September	7.19	43.99	316
2018	April	7.81	26.48	206.78

7.6.1.2 Distribution and Biomass in 2018

The biomass of native oysters, corrected for dredge efficiency of 35%, in Lough Swilly in April 2018 was 232 tonnes. About 21 tonnes of this was over the minimum legal size (Figure 33 Table 7.4).

Table 7.4. Biomass of native oyster in Lough Swilly in April 2018. DE = dredge efficiency

Native Oyster	mean	median	95% CL
Biomass_	80.79	80.80	62.76
Biomass DE 35% correction	232.49	230.19	178.19
Biomass_>76mm	7.57	7.46	2.97
BiomassCorr>76mm DE35% correction	21.06	20.92	7.37

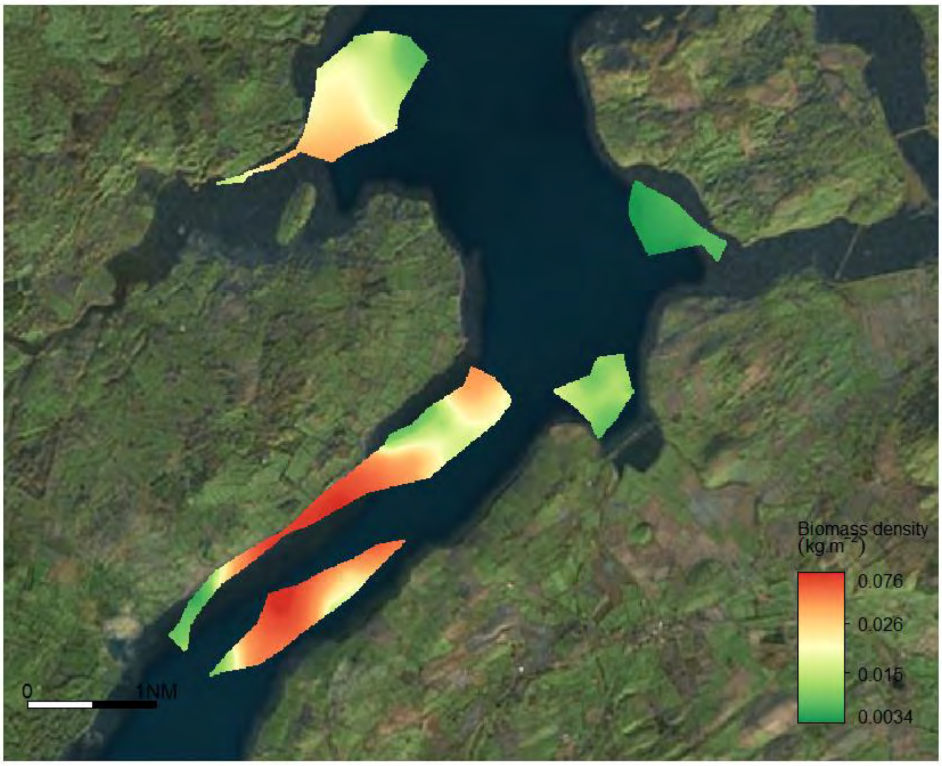

Figure 33. Distribution and density of native oysters (*Ostrea edulis*) in Lough Swilly in April 2018. Corrected for dredge efficiency of 35%.

7.6.1.3 Size distributions

Oysters between 20-40 mm were common in the survey suggesting significant settlement of spat in 2017 (Figure 34). There was also a mode at approximately 60 mm but oyster density declined between 65 mm and 76 mm suggesting significant mortality of oysters in this size range. Oysters over the minimum landing size were uncommon. The size distribution in April 2018 and September 2017 were similar although the left shift in the distribution of oysters 65-76 mm indicated on going mortality between the two surveys.

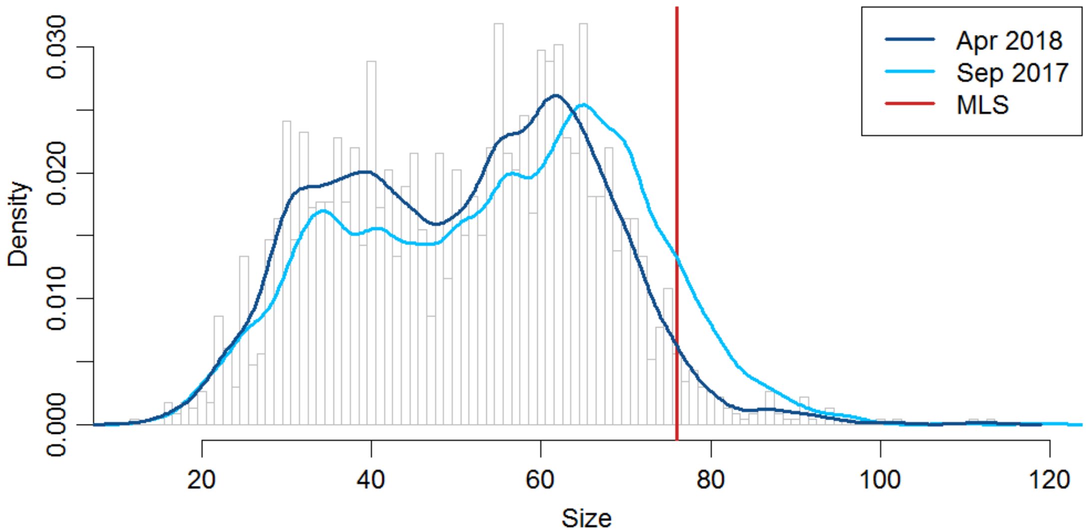

Figure 34. Size distribution of native oysters in Lough Swilly in April 2018.

7.6.2 Pacific oyster

7.6.2.1 Distribution and biomass of Pacific oyster (*Magallana gigas*) 2018

Naturalised pacific oysters occurred throughout the survey area in 2018 and particularly in Delap Bay (west shore). The estimated biomass was 1,128±213 tonnes (Figure 35, Table 7.5). The size distribution was bi-modal with a cohort, probably from a settlement in summer 2016 and 2017, and a larger mode which may include a number of age classes (Figure 36).

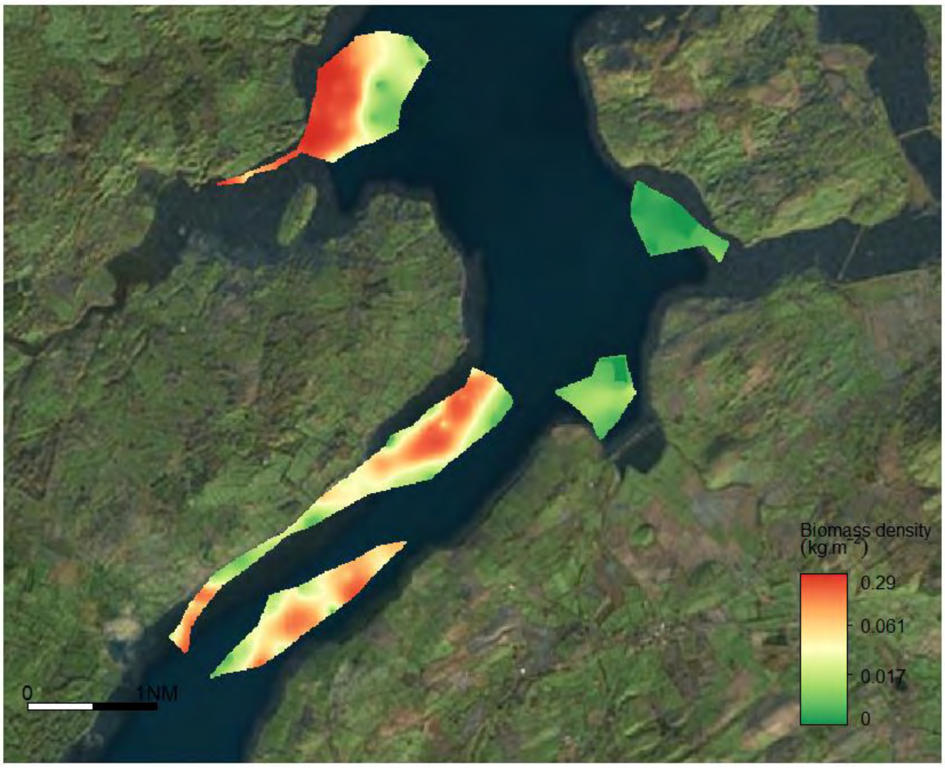

Figure 35. Distribution of Pacific oysters in Lough Swilly in 2018.

Table 7.5. Biomass of Pacific oysters in Lough Swilly in April 2018 corrected for a dredge efficiency of 35%

Biomass Strata	Area km^2	Stations	Mean Biomass	95% CL Lower	95% CL Upper
[0,0.01]	1.701	40	0.35	0.05	0.99
]0.01,0.061]	3.444	43	289.08	244.02	337.17
]0.061,0.289]	2.663	41	837.73	744.68	936.81
Total	7.8	124	1,128.08	1,024.64	1,237.90

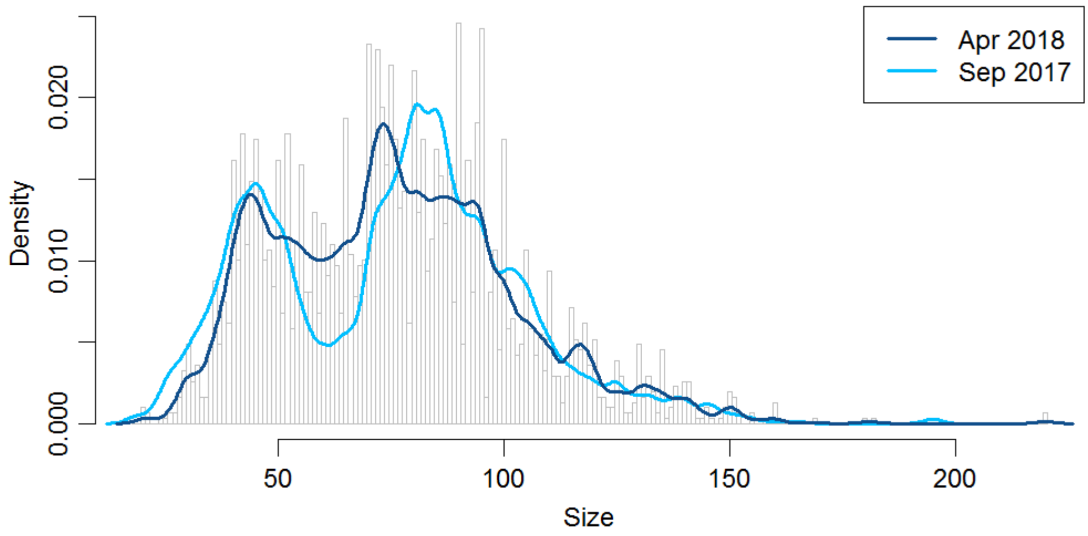

Figure 36. Size distribution of Pacific oysters in Lough Swilly in 2018.

7.6.2.2 The ratio of native oyster to pacific oyster

The ratio of native oysters to Pacific oysters varied through the survey area. Pacific oysters were dominant (biomass) at Ballybegley, south of Ballygreen Point and in Delap Bay (west shore). These areas have been fished in previous years and an unknown tonnage of Pacific oysters were removed. The market price for these oysters was uncommercial in 2018 and the rate of fishing declined (Figure 37).

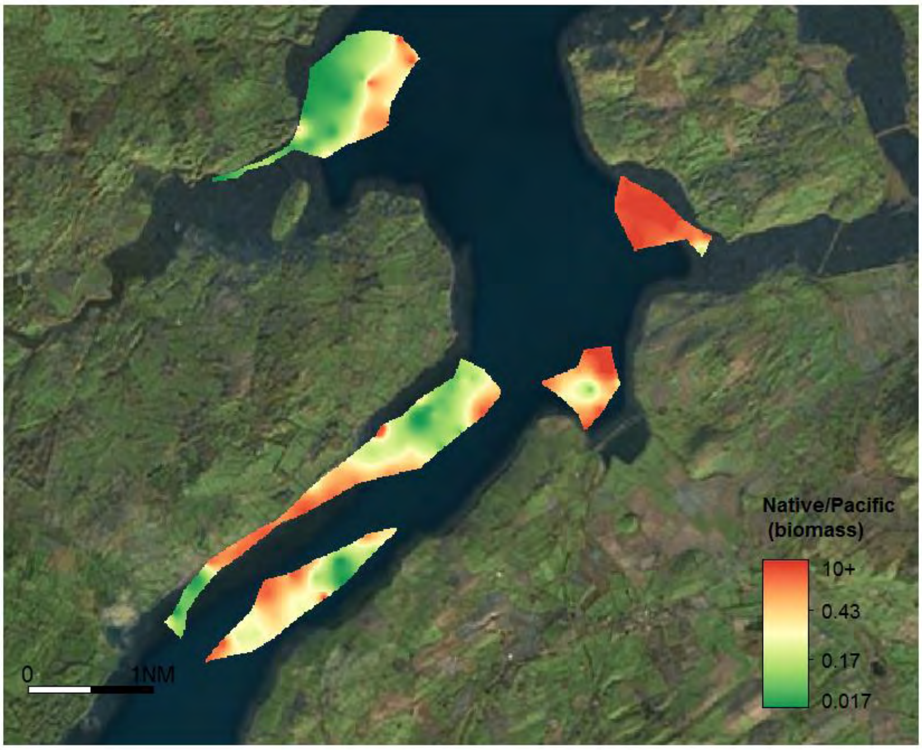

Figure 37. Distribution of the ratio of biomass of native and pacific oysters in Lough Swilly in April 2018. Red areas (higher ratio values) are areas where native oysters are dominant.

7.7 *Galway Bay*

7.7.1 Stock trends

Other than in 2011 the annual surveys have concentrated on the areas commercially fished in December north east of Eddy Island. The survey area is about 1 km^2. Biomass in 2016-2018 was higher than in the years 2011-2015 (Table 7.4).

Table 7.6. Stocks biomass trends for native oyster at Galway Bay 2011-2018

Year	Month	Survey Area (km^2)	Biomass km^{-2}	Biomass
2011	April	2.46	14.05	34.56
2012	February	1.17	24.52	28.69
2012	November	1.11	49.77	55.25
2013	November	1.02	42.94	43.8
2014	November	0.91	65.12	59.26
2016	March	0.73	106.85	78
2017	November	0.71	148.59	105.5
2018	October/November	0.72	97.78	70.4

7.7.2 Survey November 2018

The survey area reported here was limited to the area north east of Eddy Island where the fishery usually takes place. Thirty six tows of approximately 50 m length were undertaken on a 200 m grid using a standard oyster dredge.

Additional intertidal quadrat and sub-tidal dredge surveys were completed in 2018 and continued into spring of 2019 to assess the distribution and abundance of native oysters in previously fished areas. These surveys will be reported in 2019. These surveys were part of a broader project on the restoration of oysters in Galway Bay.

7.7.2.1 Biomass

Total biomass, assuming a dredge efficiency of 35%, was estimated to be 71 tonnes within the 0.75 km^2 survey area (Figure 38, Table 7.7). However, only an estimated 3 tonnes was over the MCRS of 76 mm. Although there was no fishery between the 2017 and 2018 surveys biomass declined during the period.

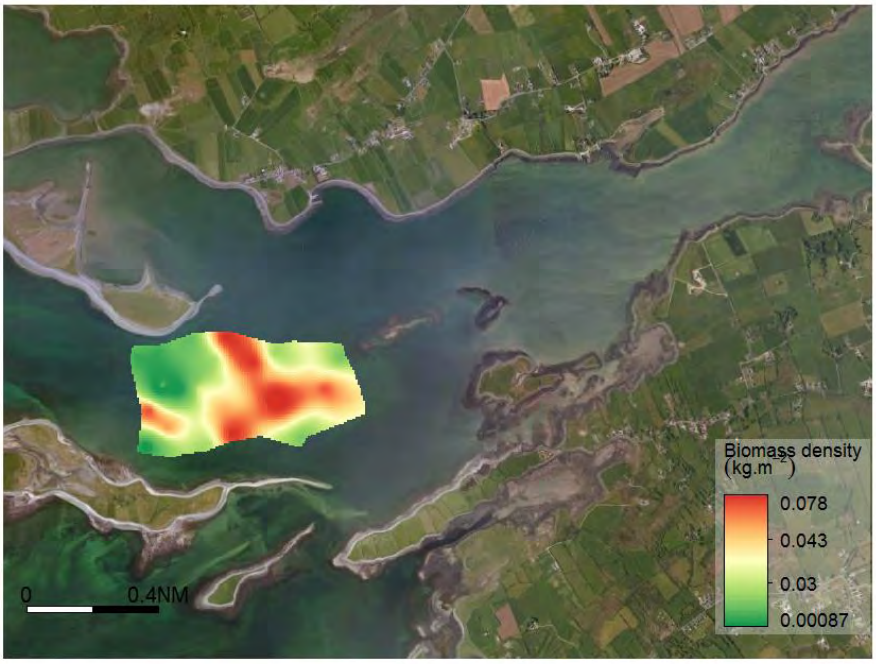

Figure 38. Distribution and biomass of native oyster seaward of the Clarin River estuary in south east Galway Bay in November 2018.

Table 7.7. Biomass of native oyster in inner Galway Bay in November 2018 based on a dredge efficiency of 35%

Native Oyster	mean	median	95% CL Lower	95% CL Upper
Biomass	71.43	71.51	64.37	79.07
Biomass >76mm	3.23	3.23	2.25	4.24

7.7.2.2 Size distribution

Spat falls were not significantly evident in the 2017 or 2018 November surveys. In year spat fall would be represented by oysters approximately 10 mm in size. Spat fall was however detected in surrounding areas on small scale trials with cultch (clean shell) suspended in the lower intertidal area (unpublished) in 2018. The mode at 35-40 mm in 2017 was at 50-55 mm in 2018 but there was no increase in the abundance of oysters over 60 mm suggesting high mortalities in these size classes (Figure 39).

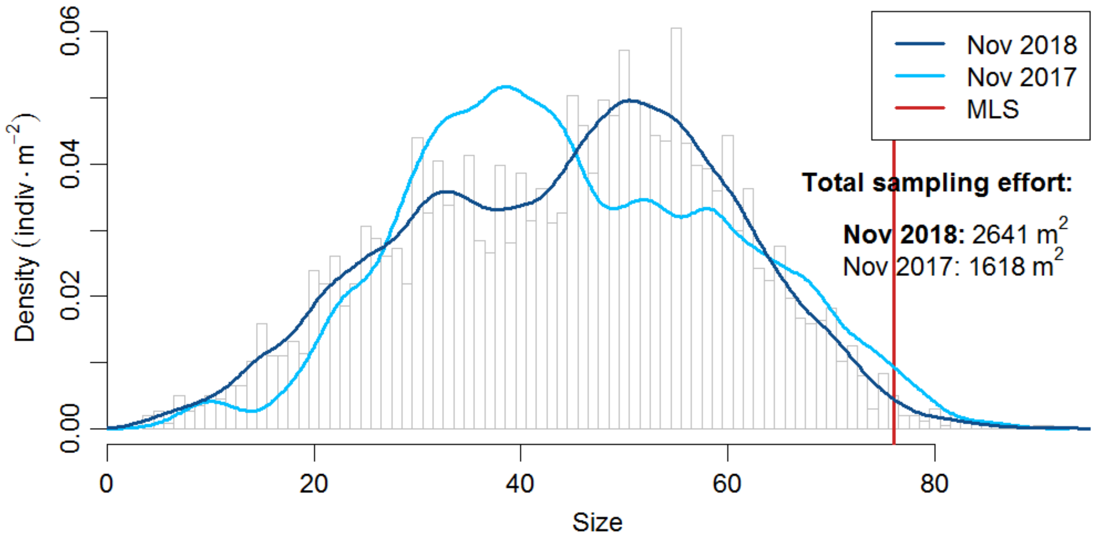

Figure 39. Size distribution of native oysters (*Ostrea edulis*) in south east Galway Bay in November 2017 and 2018. The minimum landing size (76 mm) is shown.

8 Scallop (*Pecten maximus*)

8.1 Management advice

Offshore scallop stocks in ICES Area VII are fished by Irish, UK and French fleets. There is no international assessment. Spatially referenced nominal catch rate indicators are developed for the Irish fleet in the Celtic Sea, Irish Sea and English Channel. Some inshore stocks are assessed by survey which provides biomass estimates under certain assumptions regarding catchability.

Effort distribution across stocks varies annually. From 2006-2012 catch rates increased for all stocks but declined in the period 2013–2016 in the Celtic Sea and Irish Sea, with recovery in some areas seen in 2017. Catch rates in the Eastern English Channel (French waters) have been significantly higher than other areas in recent years. This stock is recruitment driven and the fishery relies on 1-2 age classes only.

Fishing effort / landings should be managed at the stock level in proportion to changes in spatially referenced catch rate indicators, using data for all fleets, until more comprehensive assessments are developed. Optimising yield of recruited scallop by controlling size at first capture and fishing mortality requires finer scale management units.

Inshore scallop fisheries can have significant negative effects on marine habitats such as geogenic and biogenic reef. Spatial management of scallop fishing should be used to protect such habitats. Offshore scallop fisheries occur mainly on less sensitive sedimentary habitats.

8.2 Issues relevant to the assessment of scallop

No analytical assessments are currently undertaken. Limited size and age data are available from opportunistic sampling of landings from Irish vessels and a series of annual surveys undertaken in the period 2000-2005 and in 2018 in the Celtic Sea. Spatial variability in growth rates in particular indicates the need for a spatially explicit approach to assessment and, therefore, the need for spatially explicit and systematic sampling programmes.

A number of other approaches to assessment have been explored including depletion assessment of commercial catch and effort data with variable success. The main uncertainty in survey estimates is catchability which varies according to ground type. Surveys carried out in the Celtic Sea in 2017 and 2018, and which will continue in 2019, have indicated that scallops are present in densities up to five times higher on sediments comprised mainly of gravel when compared to sand.

8.3 Management Units

Offshore scallop in the Irish Sea, Celtic Sea and western and eastern Channel are spatially discrete stocks (Figure 40) following settlement but are variously interconnected during larval dispersal. Larval dispersal simulations show strong connectivity between the south Irish Sea and north east Celtic Sea, limited east west connectivity across the south Irish Sea between stocks off the Irish coast and Cardigan Bay in Wales and general separation of stocks in the eastern Irish Sea and Isle of Man from stocks further south.

Inshore stocks are small and limited in distribution within Bays on the south west and west coasts and are regarded as separate populations to the offshore stocks.

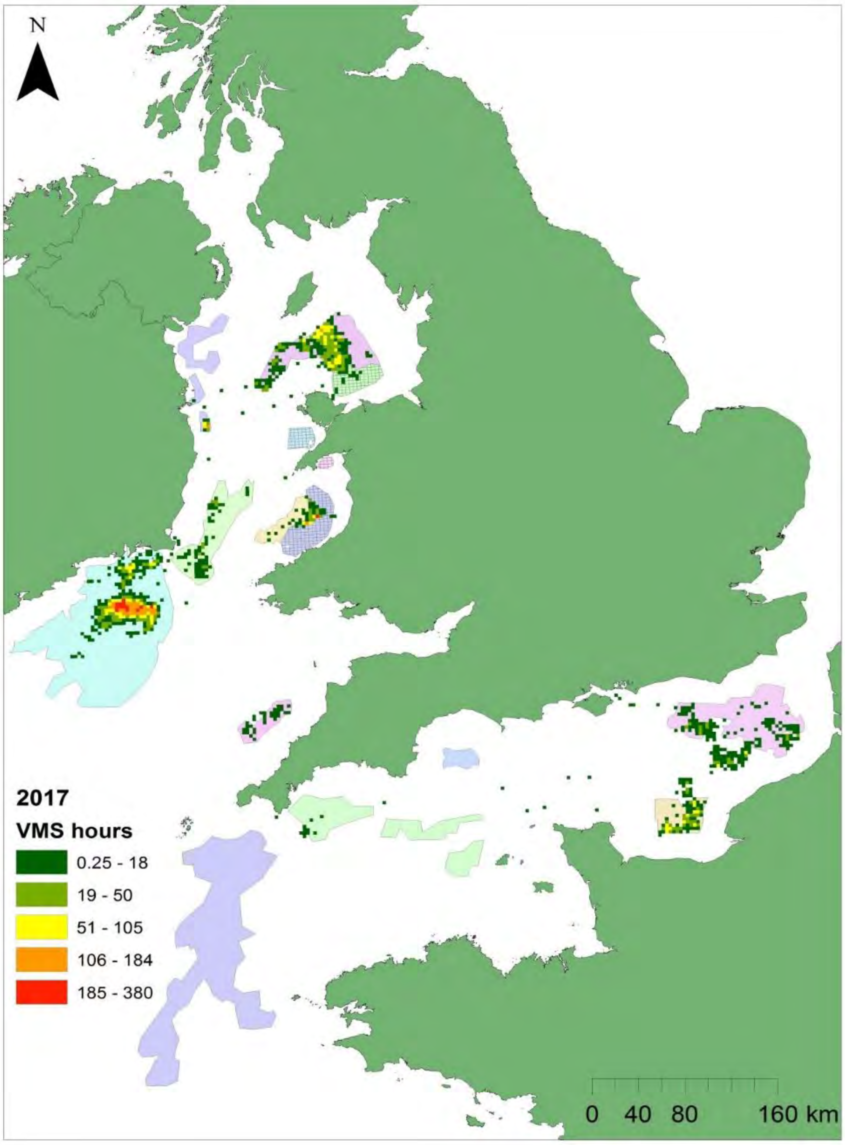

Figure 40. Offshore scallop grounds in the Irish Sea, Celtic Sea and English Channel. Boundaries are defined from the distribution of fishing activity by the Irish fleet 2000–2015 as shown by VMS data and some UK VMS data. The stock boundary limits are likely to be larger especially in the Irish Sea and English Channel considering that the UK and French fleets fish mainly in these areas. VMS data for 2017 (raster 3 km^2 grid) are shown relative to distributional extent of the stocks.

8.4 Management measures

The capacity of the scallop fleet over 10 m in length has been limited (ring fenced) since 2006 and an authorisation is required to fish for scallop. The total annual effort (Kwdays) of the fleet is also capped by the Western Waters agreement (EC 1415/2004). Given the relationship between vessel length and dredge number the number of dredges in the fleet can be predicted annually from the length of the vessels authorised (Figure 41). In 2017 the number of dredges on vessels over 10 m was estimated to be approximately 192 compared to an estimated 518 dredges prior to decommissioning of part of the fleet in 2006. Vessels under 10 m in length are unrestricted.

The minimum landing size is 100 mm shell width for most of the offshore stocks other than those in the south Irish Sea where the size is 110 mm. The minimum size for inshore stocks is generally 100 mm although sizes of up to 120 mm are used locally by agreement or as conditions established by shellfish co-operatives that may have aquaculture licences or fishery orders to manage scallop stocks locally eg. Kilkieran Bay.

Scallop fishing is excluded from areas supporting sensitive habitats. These include seagrass and maerl communities in Roaringwater Bay and reef communities in Blacksod Bay, south of Saltee Islands and south of Hook Head SACs.

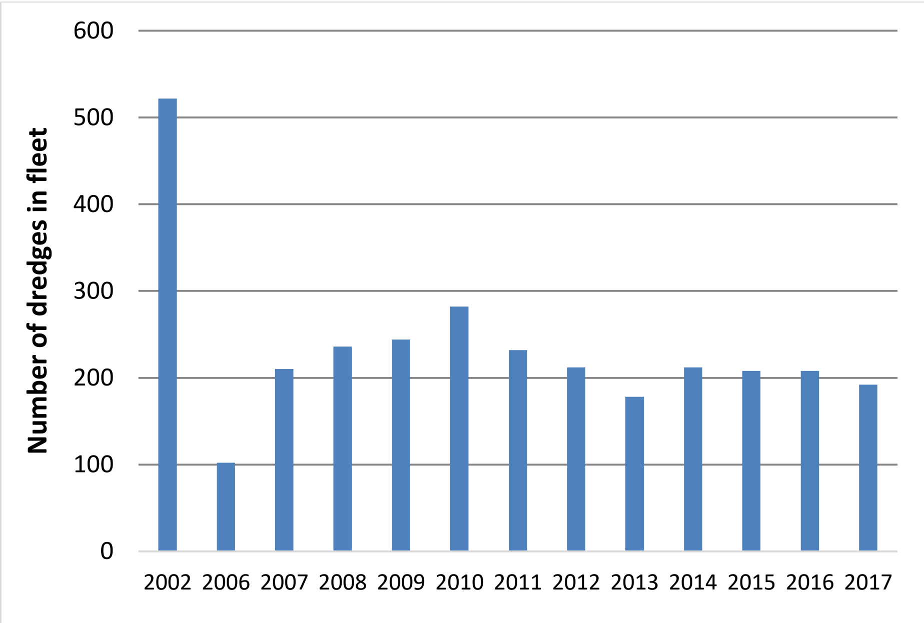

Figure 41. Annual estimated number of dredges in the authorised Irish fleet of scallop vessels over 10 m, 2002 and 2006–2017 based on the relationship between vessel length and number of dredges (Dredges = 0.88* Boat length). The fleet was partly decommissioned in 2006.

8.5 Offshore scallop fisheries

8.5.1 Landings

Landings increased from 1995–2004 due to fleet expansion and expansion of the geographic area fished off the south east coast. The fleet was decommissioned in 2006 and restricted in capacity thereafter and landings consequently declined. New vessels entered the fleet after 2006 and landings continued to increase to an all-time high of over 3,000 tonnes in 2013. Landings declined in years 2014 and 2015, but have since risen consecutively in 2016 and 2017 (Figure 42).

The Irish fleet fishes in the Irish Sea, Celtic Sea and English Channel. The majority of landings are from the Celtic Sea stock, although the Eastern English Channel has become an increasingly important area to the fleet in recent years. Fishing in the English Channel is generally episodic; in recent years the fleet has fished in the eastern Channel while in the period 2000–2006 the fleet fished in the western Channel (Figure 43).

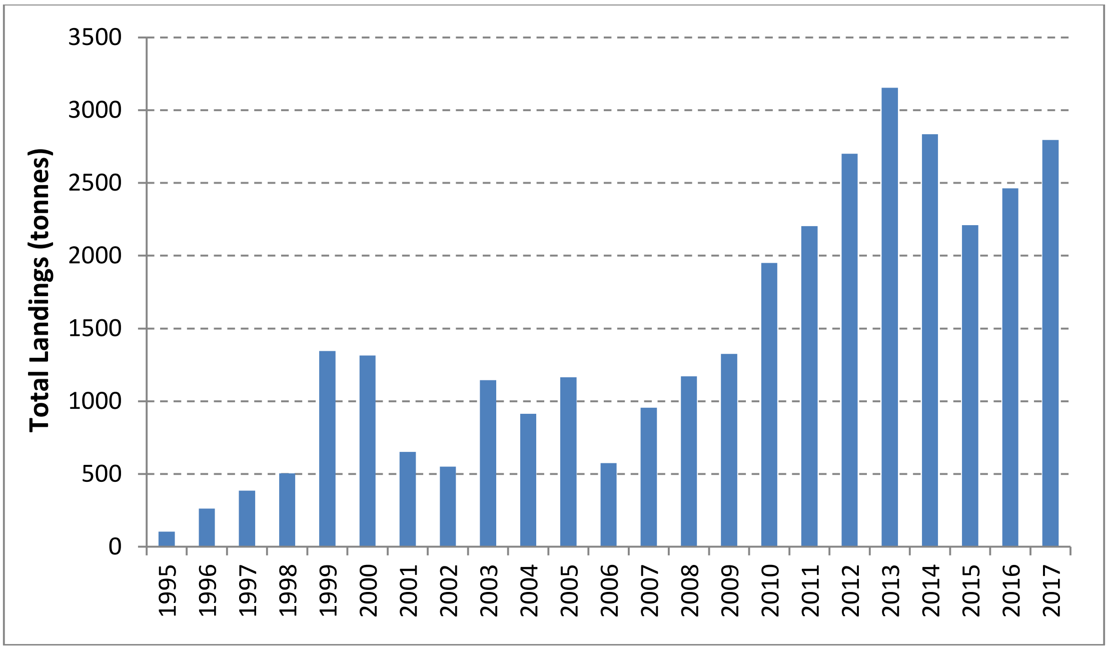

Figure 42. Annual landings of scallop into Ireland 1995–2017.

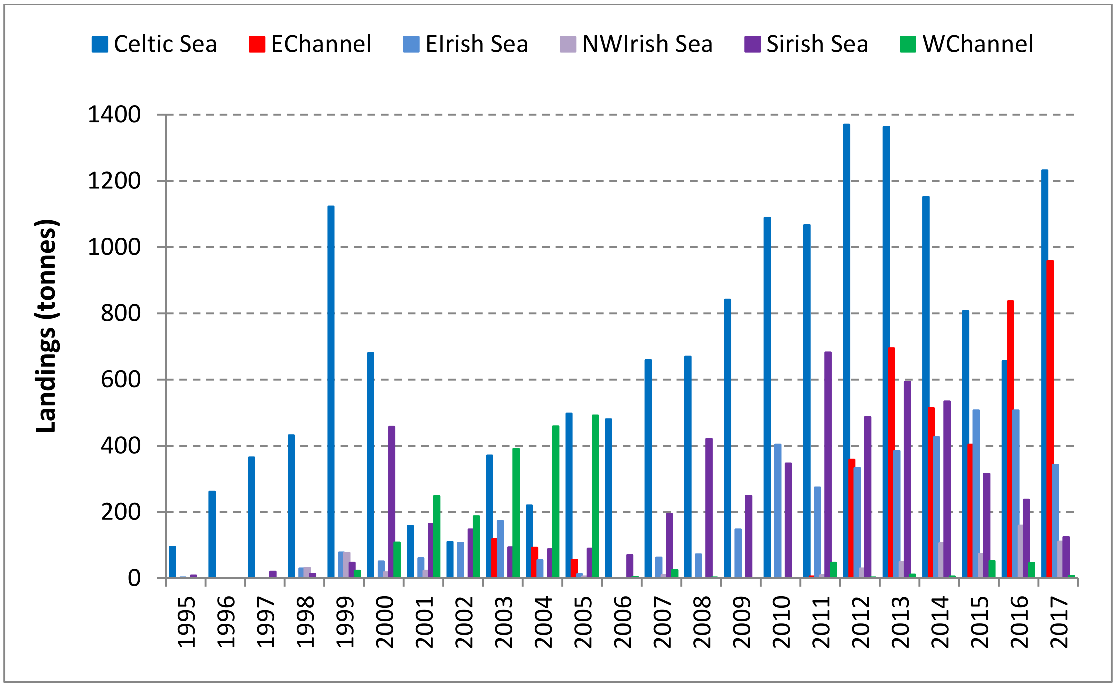

Figure 43. Annual landings by Irish fleet from stocks in the Celtic Sea, Irish Sea and English Channel areas 1995–2017.

8.5.2 Catch rate indicators

Catch rates ranged from 30–60 $kgs.dredge^{-1}.day^{-1}$ up to 2006 and increased to 80–100 $kgs.dredge^{-1}.day^{-1}$ by 2012. Catch rates declined between 2012 and 2016 in most areas, but recovered in 2017 with the exception of the Eastern Irish Sea which has experienced declining catch rates since 2009. Catch rates declined in the Western English Channel in 2017, although landings and effort in this area has been negligible in recent years. The most notable and major catch rate trend of recent years is in the Eastern English Channel where catch rates peaked at 240 $kgs.dredge^{-1}.day^{-1}$ in 2016 (Figure 44). In 2017, although catch rates in the Eastern English Channel had decreased, they were still almost three times higher than those observed from any other area, making it by far the most productive area targeted by the Irish fleet. The Irish fleet typically fish in this area during winter months (November–February).

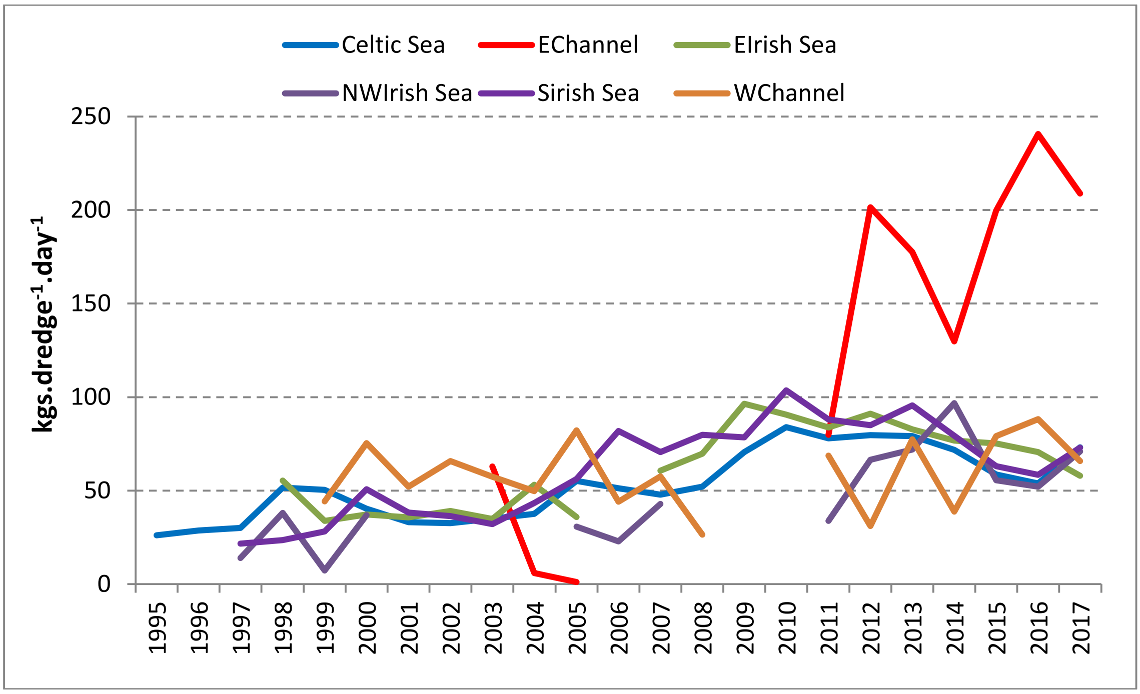

Figure 44. Annual average catch rate (kgs.dredge^{-1}.day^{-1}) of scallop in offshore scallop stocks 1995–2017.

9 Spatial restrictions on fisheries for environmental protection (Natura)

9.1 Article 6 (Habitats Directive) Assessments and Mitigations

Article 6.2 of the EU Habitats Directive requires that European member states take appropriate steps to avoid deterioration of natural habitats and species which are subject to conservation objectives within Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) (Natura 2000 sites). Furthermore, Article 6.3 of the Directive requires that any plan or project (in combination with any other activity) likely to have a significant impact on a Natura 2000 site shall be subject to Appropriate Assessment of its implications for the site in view of the site's conservation objectives.

In Ireland the Minister for Agriculture, Food and the Marine is responsible for ensuring sea-fishing activities are conducted in a manner that avoids the deterioration of designated features of Natura 2000 sites and the significant disturbance of protected species within those sites. The EU Directives are transposed into Irish law in SI 477/2011 and SI 290/2013 and places legal obligations on the Minister to manage sea-fisheries in a manner that is consistent with the conservation objectives for habitats and species designated in the Natura network. To inform these obligations risk assessments and appropriate assessments are undertaken which identify the likelihood of significant effects of fisheries on habitats and species.

The Marine Institute, as directed by the Minister, concluded assessments of the risks posed by sea-fisheries to habitats and species in SACs in 2015 (http://www.fishingnet.ie/sea-fisheriesinnaturaareas/concludedassessments/). Subsequently the Marine Institute, in consultation with DAFM, Marine Agencies and the fishing industry at local level, set about designing mitigation measures in sites where certain fisheries had been identified as posing significant risk to habitats (and with a risk of habitat deterioration). This process is ongoing.

9.2 Fisheries Natura Declarations

When the Minister considers that fisheries in a given site pose a risk to habitats and species for which the site is designated and that these fisheries need to be changed in some way to mitigate or reduce their possible impacts a Fisheries Natura Declaration (FND) is published. The FND is usually developed in consultation between the Marine Agencies and the Industry. The Declaration sets out the measures that should be followed by fisheries to mitigate their potential effects on habitats and species. The declaration is a legal instrument (http://www.fishingnet.ie/media/fishingnet/content/fisheriesinnaturaareas/siteassessments/proceduresandmethodology/NATURA%202000%20procedures%2011-9-2013.pdf)

9.3 Site specific Fisheries Mitigation Measures

Site specific mitigation measures have been established, or are proposed, for SACs as set out below. Further details are available at http://www.fishingnet.ie/sea-fisheriesinnaturaareas/natura2000sitesundermanagement/.

9.3.1 Roaringwater Bay

FND 1 of 2015 sets out mitigation measures for the protection of seagrass and maerl habitats and protected species from fisheries using mobile bottom towed fishing gears and set nets in Roaringwater Bay SAC. These measures are

1. Prohibition on dredging and trawling in specified areas (Figure 45)
2. Requirement to transmit GPS position while fishing with dredges or trawls in the SAC
3. Requirement to notify the SFPA of an intention to fish with set nets within the SAC. This is to facilitate observer programmes on by-catch of protected species (seals and Harbour Porpoise) in the Bay.

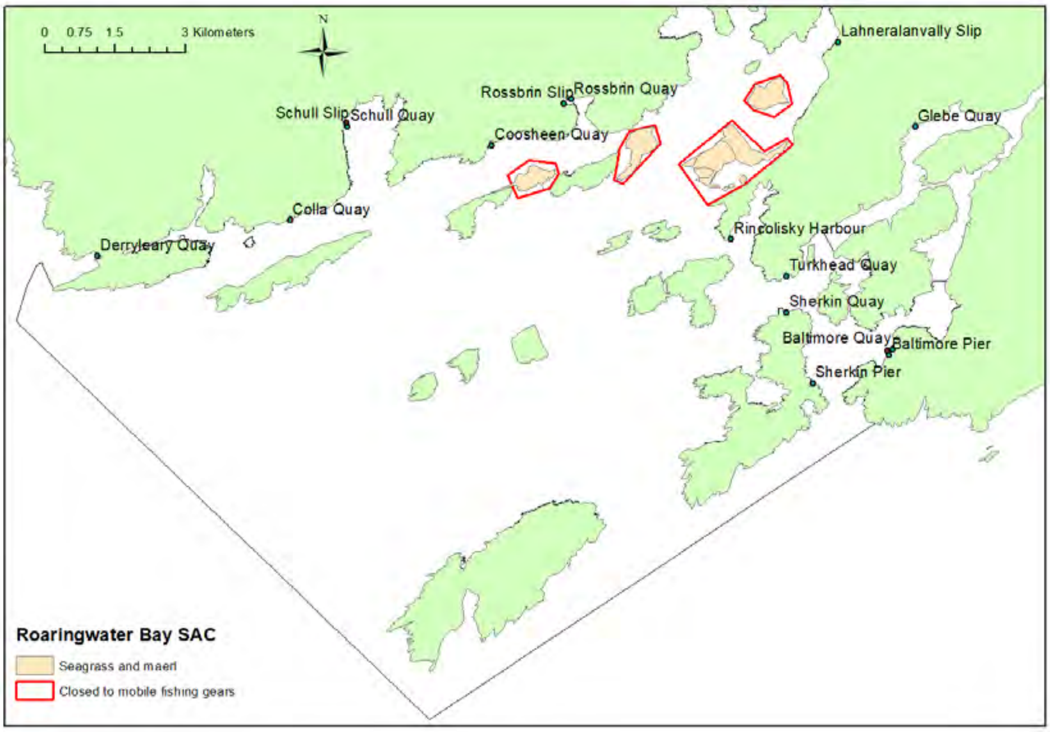

Figure 45. Roaringwater Bay SAC extent. Areas closed to dredge and trawl fishing gears to protect sensitive seagrass and maerl habitats are shown (Coordinates are set out in FND 1/2015).

9.3.2 Saltee Island and Hook Head

FND 3 of 2017 sets out mitigation measures for the protection of reef and sedimentary habitats, for fisheries using mobile fishing gears in Saltee Island and Hook Head SACs. These measures are

1. Prohibition on dredging and trawling within specified areas as shown in Figure 46. This measure effectively excludes mobile bottom towed fishing gears from a high proportion of reef habitat in the SACs.
2. Fishing with mobile gears is prohibited within the boundaries of the SACs between Mar 1st and Nov 30th in any year. This allows for a limited fishing season in December and February inclusive. The main fishery in this area is dredging for scallop. This is to enable recovery of sedimentary habitats between fishing seasons.

3. Vessels fishing with mobile gears in the SACs, excluding the closed areas, during the period December-February inclusive, should report GPS position while fishing. Vessels, including those over 12 m should report position at least every 10 minutes. This requirement is to monitor compliance with the closed areas and closed season.

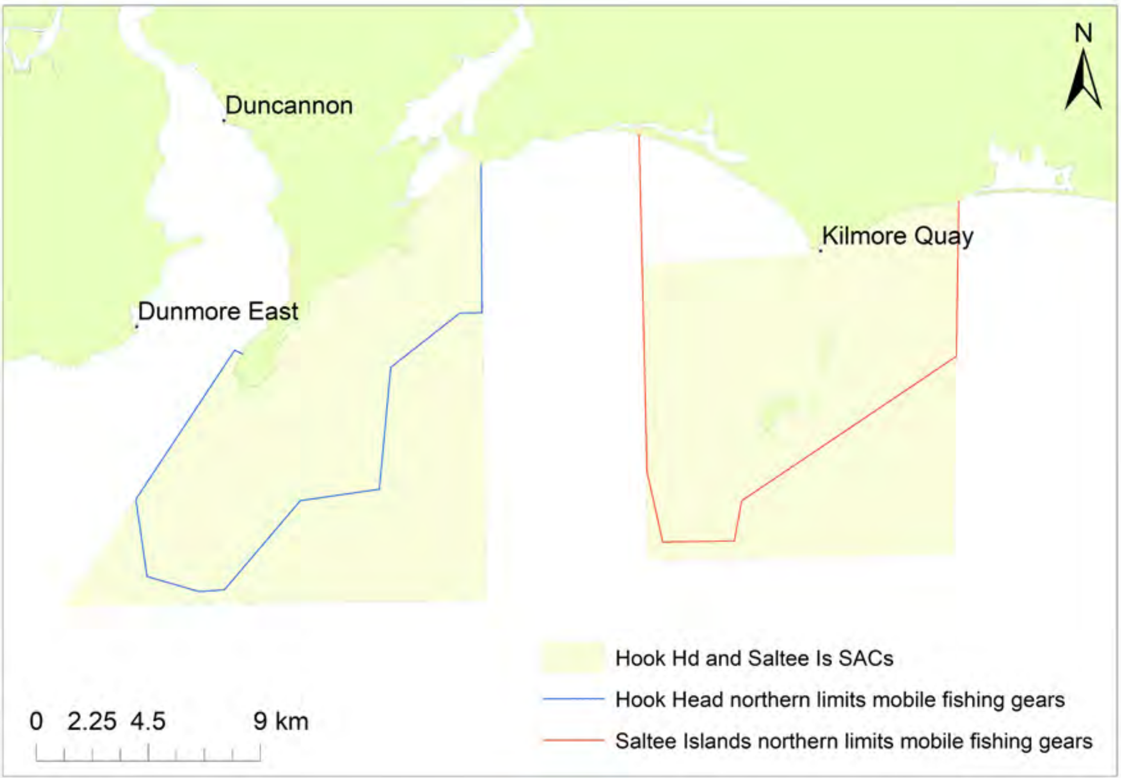

Figure 46. Hook Head and Saltee Is SACs extent. Areas closed to dredge and trawl fishing gears to protect sensitive reef habitats are shown (Coordinates are set out in FND 1/2015).

9.3.3 Blacksod Bay

FND 3 of 2015 sets out mitigation measures to protect scallop stocks and also reef (*Serpula vermicularis*), maerl, seagrass and sedimentary habitats in Blacksod Bay. These measures are

1. No fishing for scallop in areas open to mobile towed fishing gears from Oct 1st 2015 to Oct 1st 2016. New legislation in 2019 will continue the closure of the fishery.
2. Fishing for scallop cannot occur in areas outside the specified zone shown in Figure 47. This is to protect reef, seagrass and maerl habitat.
3. Vessels with scallop gears on board and fishing in Blacksod Bay should report GPS position while fishing at a frequency of up to 1 minute.

New measures are being developed for oyster fishing.

Figure 47. Blacksod Bay SAC extent. The area open to scallop fishing gears, provided the scallop fishery is open, is shown (co-ordinates are set out in FND 3/2015).

9.3.4 Clew Bay

Proposals set out below were agreed through consultation with the fishing industry in Clew Bay in 2018. These are not yet incorporated into legislation.

9.3.4.1 Scallop Dredging and trawling

1. No Scallop fishing or bottom trawling to occur south of a line extending east from the Cloughcormick Buoy (Figure 48).
2. A maximum of 3 aside (6 per vessel) scallop dredges shall apply to vessels fishing in Clew Bay
3. Scallop fishing will continue to be seasonal

These measures would minimise the overlap between scallop fishing and components of reef habitat. An overlap with 6% of the area of kelp habitat would remain.

9.3.4.2 Oyster Dredging

1. No fishing for oysters in the southern section of the Clew Bay SAC as shown in Figure 49. This will remove any overlap between oyster fishing and sensitive habitats maerl or seagrass.
2. Oyster fishing in sedimentary habitats will occur only between October to March inclusive to enable recovery of fauna between fishing seasons. Usually the number of fishing days is 15-25 per annum.
3. Each boat will use 1 dredge only which will not be wider than 1.2 m.

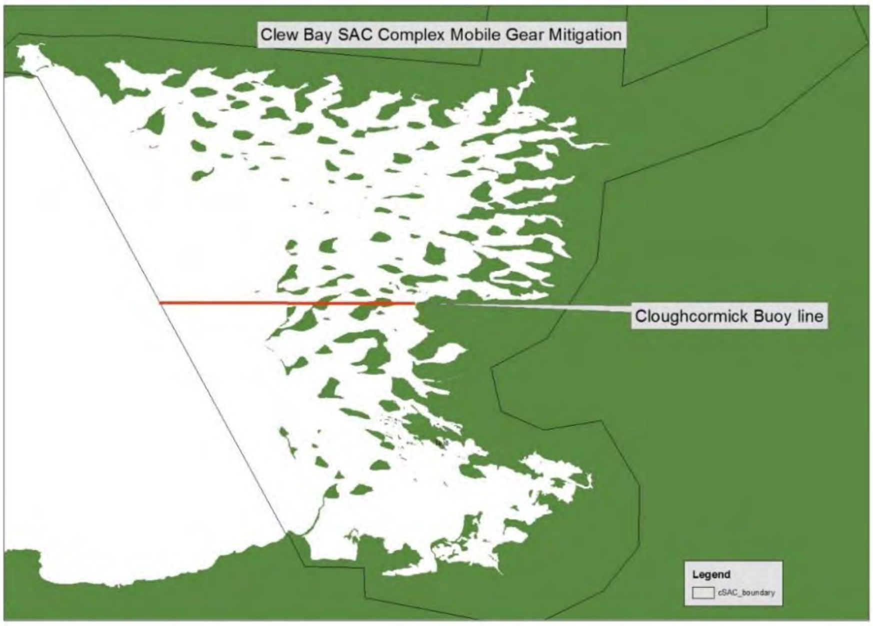

Figure 48. Clew Bay SAC extent. Scallop fishing and the use of other towed mobile gears (other than oyster dredging) would be excluded from areas south of the Cloughcormick Buoy line within the SAC.

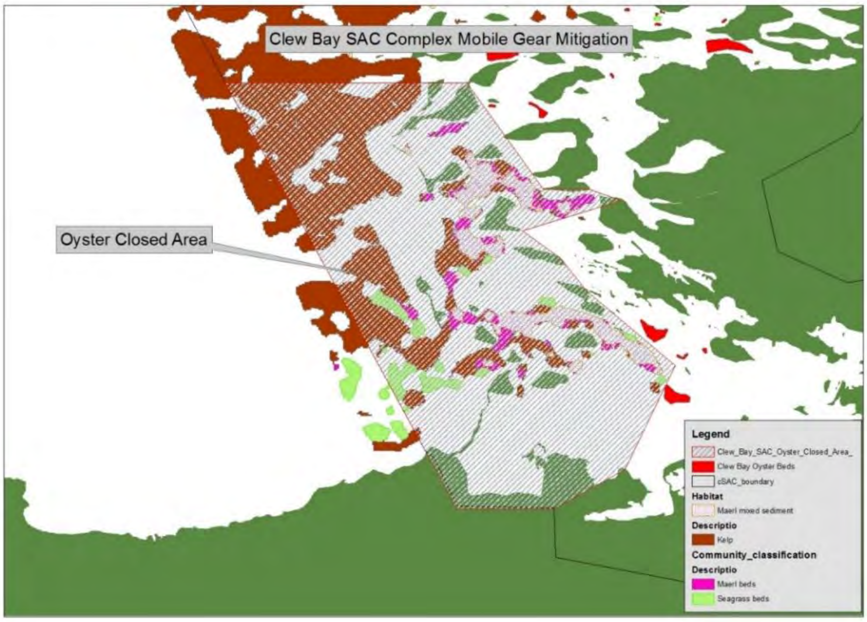

Figure 49. Clew Bay SAC extent. Oyster fishing would be excluded from the shaded areas. Kelp, seagrass and maerl habitats are shown.

10 Glossary

Accuracy A measure of how close an estimate is to the true value. Accurate estimates are unbiased.

Benthic An animal living on, or in, the sea floor.

Bonamia (ostrea) A parasite of native oyster which infects the blood cells and causes mortality of oysters.

Biomass Measure of the quantity, eg metric tonne, of a stock at a given time.

Bi-valve A group of filter feeding molluscs with two shells eg scallops, cockles.

Cohort (of fish) Fish which were born in the same year.

Cohort analysis Tracking a cohort of fish over time. Length cohort analysis tracks length classes over time using growth data

Demersal (fisheries) Fish that live close to the seabed and are typically targeted with various bottom trawls or nets.

Ecosystems are composed of living animals, plants and non living structures that exist together and 'interact' with each other. Ecosystems can be very small (the area around a boulder), they can be medium sized (the area around a coral reef) or they can be very large (the Irish Sea or even the eastern Atlantic).

Exploitation rate The proportion of a population at the beginning of a given time period that is caught during that time period (usually expressed on a yearly basis). For example, if 720,000 fish were caught during the year from a population of 1 million fish alive at the beginning of the year, the annual exploitation rate would be 0.72.

Fishing Effort The total fishing gear in use for a specified period of time.

Fishing Mortality Deaths in a fish stock caused by fishing usually reported as an annual rate (F).

Fishery Group of vessel voyages targeting the same (assemblage of) species and/or stocks, using similar gear, during the same period of the year and within the same area (e.g. the Irish flatfish-directed beam trawl fishery in the Irish Sea).

Fishing Licences A temporary entitlement issued to the owner of a registered fishing vessel to take part in commercial fishing.

Fleet Capacity A measure of the physical size and engine power of the fishing fleet expressed as gross tonnage (GTs) and kilowatts (KWs).

Fleet Segment The fishing fleet register, for the purpose of licencing, is organised in to a number of groups (segments).

Management Plan is an agreed plan to manage a stock. With defined objectives, implementation measures or harvest control rules, review processes and usually stakeholder agreement and involvement.

Management Units A geographic area encompassing a 'population' of fish de-lineated for the purpose of management. May be a proxy for or a realistic reflection of the distribution of the stock.

Minimum Landing Size (MLS) The minimum body size at which a fish may legally be landed.

Natura A geographic area with particular ecological features or species designated under the Habitats or Birds Directives. Such features or species must not be significantly impacted by fisheries.

Natural Mortality Deaths in a fish stock caused by predation, illness, pollution, old age, etc., but not fishing.

Polyvalent A type of fishing licence. Entitlements associated with these licences are generally broad and non-specific. Vessels with such licences are in the polyvalent segment of the fishing fleet.

Precision A measure of how variable repeated measures of an underlying parameter are.

Quota A portion of a total allowable catch (TAC) allocated to an operating unit, such as a Vessel class or size, or a country.

Recruitment The amount of fish added to the exploitable stock each year due to growth and/or migration into the fishing area. For example, the number of fish that grow to become vulnerable to the fishing gear in one year would be the recruitment to the fishable population that year. This term is also used in referring to the number of fish from a year class reaching a certain age. For example, all fish reaching their second year would be age 2 recruits.

Recruitment overfishing The rate of fishing, above which, the recruitment to the exploitable stock becomes significantly reduced. This is characterised by a greatly reduced spawning stock, a decreasing proportion of older fish in the catch, and generally very low recruitment year after year.

Reference points Various reference points can be defined for fished stocks. These can be used as a management target or a management trigger (i.e. point where more stringent management action is required). Examples include fishing mortality rate reference points, biomass reference points, indicator eg catch rate reference points or those based on biological observations.

Sales Notes Information on the volume and price of fish recorded for all first point of sale transactions.

Shellfish Molluscan, crustacean or cephalopod species that are subject to fishing.

Size composition The distribution, in size, of a sample of fish usually presented as a histogram.

TAC Total Allowable Catch

Vivier A fishing vessel, usually fishing for crab, with a seawater tank(s) below decks, in which the catch is stored live.

VMS Vessel Monitoring System. Vessels report GPS position periodically when fishing

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