Shellfish Stocks and Fisheries

Review 2019

An assessment of selected stocks

The Marine Institute and Bord Iascaigh Mhara

Ireland's Seafood Development Agency

Foras na Mara
Marine Institute

The data that underpins the advice provided in this book is collected under the Data Collection Framework, which is financed by the Irish government and the European Maritime & Fisheries Fund as part of the EMFF Operational Programme for 2014-2020

Ireland's EU Structural and Investment Funds Programmes 2014 - 2020
Co-funded by the Irish Government and the European Union

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

EUROPEAN UNION
European Maritime and Fisheries Fund

Acknowledgement: Data presented in this report originates from a variety of sources including voluntary submission of information by fishermen, through core funded projects from the Marine Institute, and is part supported by the Irish government and the European Maritime and Fisheries Fund as part of the EMFF Operational Programme for 2014-2020

Photographs on cover by T. Rapp (Scallop), P. Newland (Razor Clam), J. White (Lobster)

ISBN: 978-1-902895-66-6

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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 shellfish fisheries 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.

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 EU TAC and in the main, and other than crab and scallop, are distributed inside the national 12 nm fisheries limit. Management of these fisheries is within the competency of the Department of Agriculture, Food and Marine (DAFM).

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 (NIFF, 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 Aquaculture licences to local co-operatives.

The main customers for this review are DAFM, 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 2019, was 65,489 gross tonnes (GTs) and 2,004 vessels (Table 2-1). The polyvalent general segment was the largest and included 32,227 GTs and 1,393 vessels. The polyvalent potting segment had 330 registered vessels and 700 GTs while the bivalve (specific) segment had 2,266 GTs and 151 vessels. There were 10 beam trawl vessels and 23 pelagic vessels with capacity of 1,139 and 24,876 GTs respectively.

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. 28/2018.

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 2019 almost 74% 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 is negated. Potting 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 14 vessels over 10 m in length were authorised to fish for scallops in 2019.

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 330 such vessels in 2019 compared to 490 in 2007. 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 when the number of vessels declined by 98. Between 2018 and 2019 the polyvalent fleet under 13 m increased by 4 vessels. The specific segment, targeting bivalves, increased by 13 vessels between 2017 and 2018 mainly due to increased participation in the razor clam fishery but declined by 2 vessels in 2019 (Table 2-1, Table 2-3, 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 2006-2019 (<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	1,133
2007	13	999	490	93	1,595
2008	46	1,081	482	115	1,724
2009	60	1,146	474	124	1,804
2010	68	1,198	467	120	1,853
2011	78	1,239	461	118	1,896
2012	85	1,269	460	122	1,936
2013	86	1,233	454	117	1,890
2014	89	1,218	448	112	1,867
2015	89	1,226	426	123	1,864
2016	87	1,218	404	126	1,835
2017	83	1,171	363	125	1,742
2018	84	1,200	337	138	1,759
2019	80	1,204	330	136	1,750
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
2019	7.04	7.54	6.61	9.59	7.50
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
2019	2.83	3.92	2.12	7.52	3.81

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
2019	31.65	30.25	29	66.62	32.91

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. Negative values are shaded.

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
2018-2019	-4	4	-7	-2	-9
% 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
2018-2019	-4.76	0.33	-2.08	-1.45	-0.51

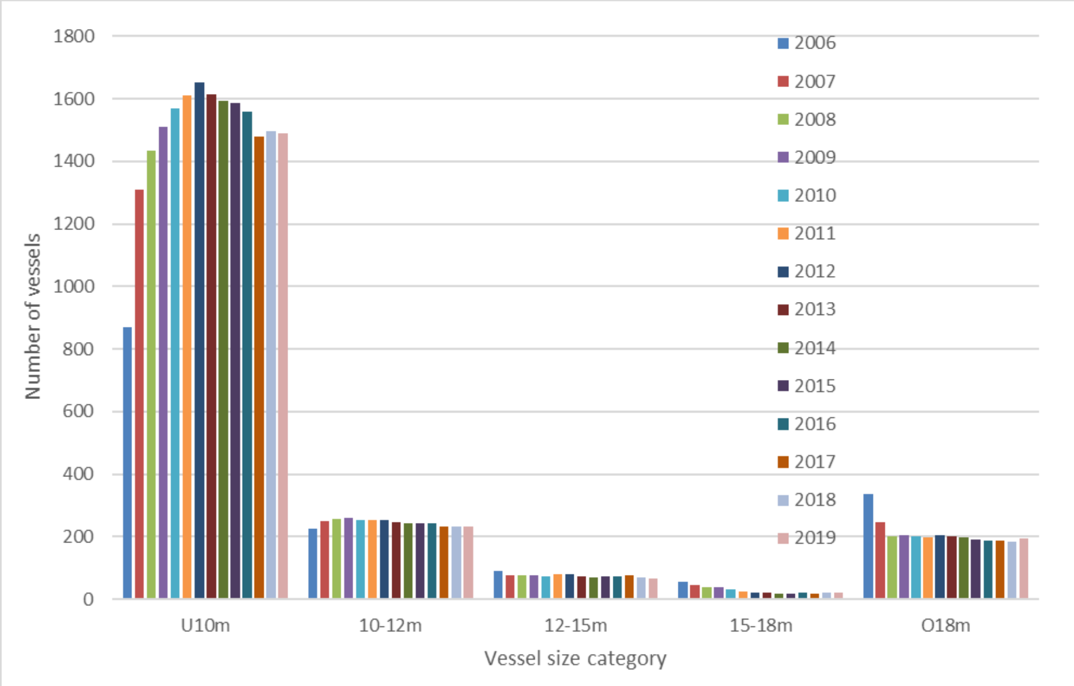


Figure 1. Annual trends in the number of fishing vessels under 13 m in length in four fleet segments 2006-2019.

3 Shellfish Landings 2004-2019

Annual landings of crustaceans and bivalves, excluding *Nephrops* and wild blue mussel (*Mytilus*) seed, which is re-laid for on-growing, during the period 2004-2019, varied from a high of 29,000 tonnes in 2004 to a low of 13,790 in 2009. Landings were just under 21,000 tonnes in 2019 (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 (818 tonnes) was substantially higher than in any previous or subsequent years. Brown crab landings in 2012 were less than half of their value in 2004 but increased substantially in 2016 before declining again in the subsequent three years. 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 SFPA 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 digitised gatherers dockets and consignment data to buyers (razor clams) provide a complete picture of landings separate to logbook data or sales notes.

Total value of shellfish landings, excluding mussel and *Nephrops*, in 2019 was approximately €63.6 million.

Table 3-1. Estimates of annual landings (tonnes) and value (€) of crustacean and bivalve shellfish (excl. prawns and mussels) into Ireland 2004-2019 (source: Logbook declarations and sales notes for vessels under 10 m, gatherer dockets, co-op data). Unit value (per kilo) is from sales note data or other sources.

Scientific Name	Common name	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Unit Price 2019	Value 2019
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	8,963	8,646	€2.18	€18,868,754
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	2,367	2,383	€5.23	€12,454,727
Homarus gammarus	Lobster	856	635	625	308	498	431	477	735	249	374	456	371	398	399	343	481	€15.50	€7,454,653
Littorina littorea	Periwinkle	1,674	1,139	1,210	609	1,141	1,103	1,280	64	103	218	1,135					4	€2.60	€10,393
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	5,449	6,221	€2.01	€12,504,422
Palaemon serratus	Shrimp	405	151	319	325	180	228	135	111	152	157	301	250	361	307	238	165	€16.91	€2,790,162
Ostrea edulis	Native oyster	543	94	233	291	88	327	349	100	100	214	265	153	190	168	150	150	€3.00	€450,000
Aequipecten opercularis	Queen scallop	110	75	172	26	4		748	1,002	1,479	285	100	31	205	48	36	702	€2.00	€1,404,000
Necora puber	Velvet crab	291	245	281	142	268	205	342	160	168	365	283	406	289	301	233	318	€2.13	€676,620
Spisula	Surf clam	28		26	14	55	150	162	73	15	37	67	48	51	45	47	44	€4.00	€176,000
Maja brachydactyla	Spider crab	180	141	153	70	153	443	415	290	818	229	210	190	108	118	105	356	€0.94	€335,418
Palinurus elephas	Crayfish	80	30	34	16	18	28	30	25	33	34	23	25	8	9	9	19	€35.00	€665,000
Ensis spp	Razor clams	400	404	547	356	451	293	410	473	428	723	1,040	840	927	1,005	487	585	€7.49	€4,381,650
Carcinus maenas	Shore crab	268	27	46	91	72	244	129	74	253	31	49	30	165	154	149	279	€0.47	€131,130
Cerastoderma edule	Cockle	207	107	7	643	9	173	5	401	400	374	3	0	321	442	446	595	€2.27	€1,350,650
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	18,711	20,948		**€63,653,579**

4 Lobster (*Homarus gammarus*)

4.1 Management advice

Lobster stocks are managed using a minimum landing size (MLS) of 87 mm, a maximum landing size (MaxLS) of 127 mm and a prohibition on the landing of V-notched lobsters. In 2019, 60 % of the reproductive potential (RP) in lobster stocks was in lobsters between 87-127 mm (legal lobsters). An additional 16 % of RP was in V-notched lobsters between 87-127 mm, 13 % of RP was protected by the MLS, 11 % was above the MaxLS with 72 % of these lobsters also being V-notched. The MLS and MaxLS therefore protects 24 % of current RP and V-notching protects a further 16 %. There is a lot of variation in these figures in different regions and across years.

Nominal stock status indicators, landings per unit effort, discards per unit of effort and V-notched lobsters per unit of effort showed stable or positive trends during the period 2013-2017 in most coastal areas suggesting that RP is enabling stable or improving recruitment. These patterns were common in both the sentinel vessel (SVP) and MI observer programmes. LPUE averaged 20 Lobsters/100 pots in 2019.

Conservation measures should be maintained. The MaxLS is a size refuge for lobsters that have previously been V-notched. Over 50 % of lobsters over the MaxLS have previously been notched. V-notching should target lobsters over 95 mm to maximise egg production prior to repair of the v-notch and should be directed to coastal areas where the prevalence of V-notched lobsters is currently low. Specific targets should be set for the proportion of the mature female lobster stock to V-notch and achievement of this figure should be monitored through logbook and observer programmes.

Reliance on the V-notch programme, which is based on voluntary participation, to protect RP should be reduced and replaced with other measures if there is any decline in uptake of the programme which should be reviewed annually.

4.2 Issues relevant to the assessment of the lobster fishery

Lobster is the most important species exploited by inshore fishing vessels in Irish inshore waters; at least 900 vessels fish for lobster and it is a high value species. Landings data may be incomplete and compromises the use of different stock assessment methods.

Lobsters cannot be aged. Size distribution data varies spatially and raising to the size distribution of the landings is difficult due to spatial variability. These data come from observers working on board lobster vessels mainly between May and October and from the SVP programme. There is also some port sampling of landings.

Growth rate data are available for Irish stocks from tag returns. Size at maturity has been estimated a number of times. Growth parameter estimates need to be reviewed.

Egg per recruit assessments have been used to compare the relative merits of different technical conservation measures; namely size limits and v-notching. Estimating the exploitation status (fishing mortality rate) on the egg per recruit curves is difficult given that this relies on size distribution data and estimates for growth and natural mortality. Reproductive potential of different size components of the stock can be estimated from size distribution, size at maturity and fecundity data. This indicates the relative contribution of different conservation measures to spawning potential and is reported below.

Catch rate indicators are available from the sentinel vessel programme which covers approximately eight percent of the fleet and from the MI observer programme. This coverage is insufficient to provide precise estimates of catch rate given the variability in these data in time and space. A number of indicators can be estimated from the data including a recruitment index and an assessment of the % of V-notched lobsters in the catch.

4.3 Management units

Lobsters are probably distributed as regional stocks along the Irish coast. In 2006 six management units were proposed based on larval dispersal modelling. Juvenile and adult lobsters do not move over large areas and the stock structure is determined mainly by larval dispersal. Genetic and larval dispersal modelling studies are ongoing through a project that will indicate the range of dispersal of progeny from v-notched lobsters released in different areas between Loop Head and Slyne Head.

4.4 Management measures

The lobster fishery is managed using technical measures. The minimum size is 87 mm carapace length. A maximum size limit of 127 mm was introduced in 2015 following an egg per recruit assessment which showed low egg production and to protect v-notched lobsters growing into larger size classes. It is prohibited to land V-notched lobsters. The v-notching of lobsters is voluntary. There are no effort or catch limits.

4.5 Stock status indicators

Stock status indicators include size distribution data, estimates of reproductive or spawning potential and catch rates. This report includes the SVP data from 2013-2017 and the MI observer data from 2015-2019. SVP catch rate data for 2018 and 2019 is not included as it is still being validated. Before 2015, observer trips were very limited and thus, catch rate data is not shown. Table 4-1 shows the number of SVP trips and observer hauls which were targeting lobster and for which data are available.

Table 4-1. Number of SVP boat days and MI Observer hauls per year targeting lobsters from 2013-2019

Sampling Type	2013	2014	2015	2016	2017	2018	2019
SVP Data (Boat days)	2,374	2,587	3,009	2,127	2,643	-	-
MI Observer Data (hauls)	-	-	683	390	664	409	362

In the SVP, landings and discards of lobsters are generally reported in either numbers or kilograms. Numbers are reported in this analysis. Weights were transformed to numbers from the mean size of landings (97 mm), discards (78 mm) and oversized (134 mm) lobsters and the modal size for V-Notched lobsters (106 mm) from observer data. A length-weight relationship from port-processor data was applied ($\mathbf{W}=1.42*10^{-6}\mathbf{L}^{2.84}$) where W is weight and L is carapace length.

4.5.1 Size distribution indicators

Size distributions of discards and landings were stable during 2015-2019 (Figure 2). Landings mostly ranged between 87-95 mm and discards between 75-86 mm. An increase in smaller size classes of discarded lobsters was observed in 2019, although less data was collected in this year. The number of lobsters over 127 mm remained low despite being more prevalent in catches in 2018. Lobsters over 150 mm were recorded in 2019.

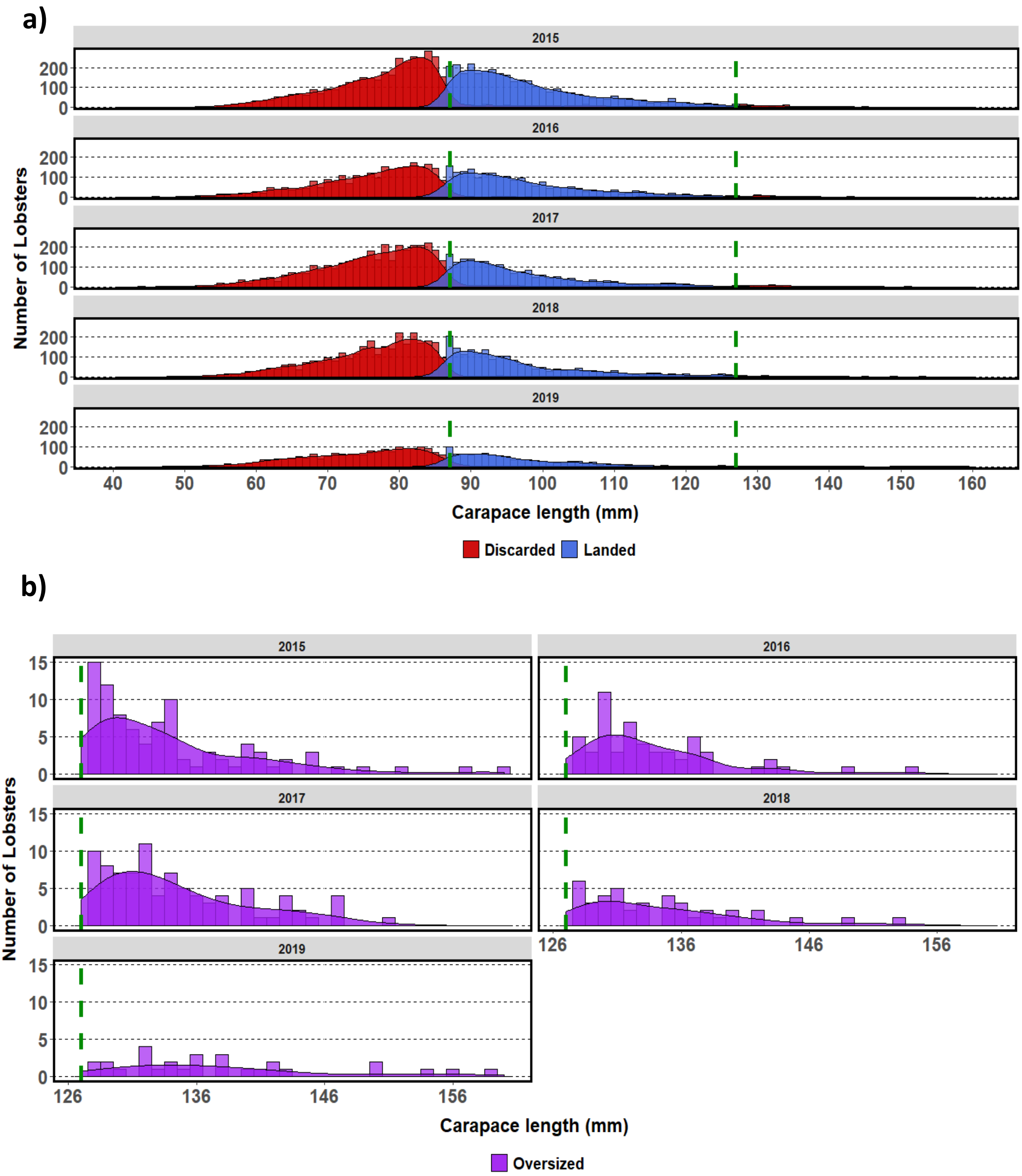


Figure 2. Histograms and density plots of lobsters by carapace length (1 mm size classes) from the MI observer data collected between 2015-2019 for a) Discarded, landed and oversized lobsters and b) Oversized lobsters only. Green dashed lines show the minimum (87 mm) and maximum (127 mm) landing sizes.

Data from the MI observer scheme for 2016-2019 is shown by county in Figure 3.

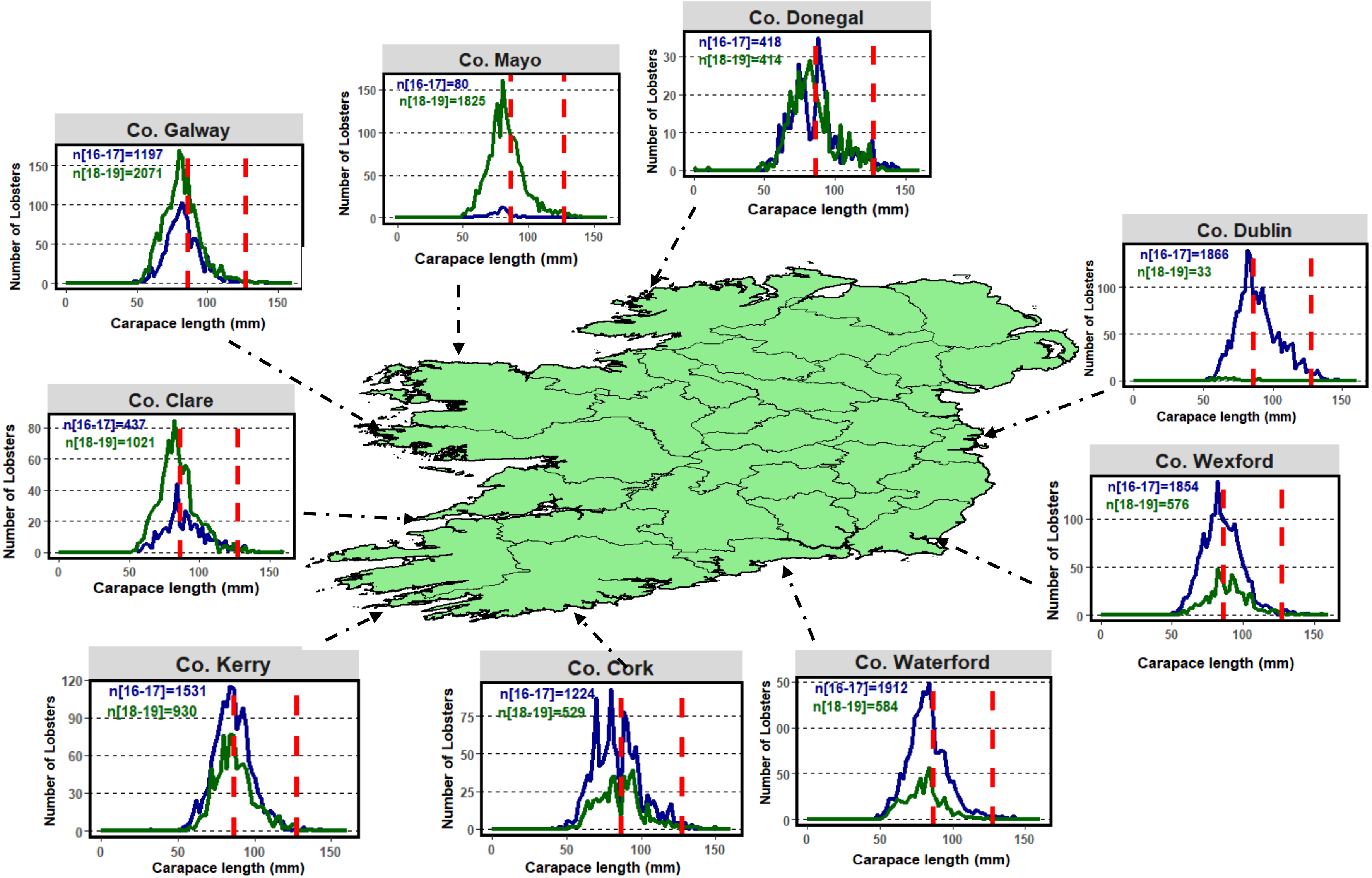


Figure 1. Size distribution of lobsters around the Irish coast sampled by the MI Observer programme between 2016-2019. Minimum and maximum landing size are shown as dashed red lines. Sample size (n) is indicated within each county plot for 2016-2017 and 2018-2019.

4.5.2 Contribution of technical measures to reproductive potential

Recapture of V-notched lobsters is recorded through the MI Observers at sea programme and the Sentinel Vessel Programme (SVP). The percentage of lobsters in the catch that are V-notched increases with size (Figure 4) from 4 % at the minimum size (87 mm) to over 50 % in size classes over the maximum size (127 mm). However, numbers of lobsters in size classes > 127 mm are low.

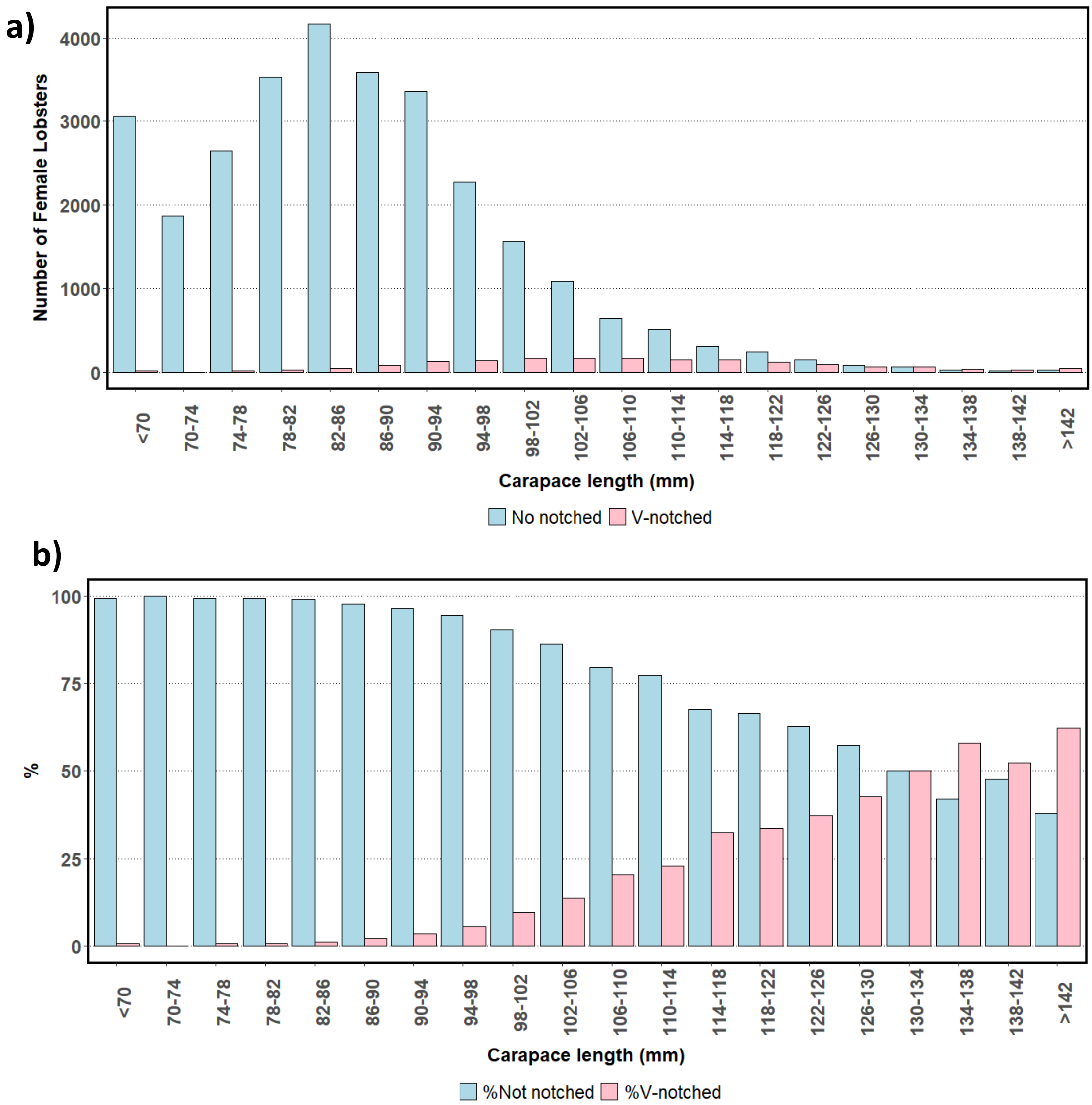


Figure 4. Size distribution as a) Number and b) Percentage of lobsters in the catch with and without V-notches from 2009-2019 from all coastal areas. Source: Marine Institute Observer data 2010-2019.

The percentage of V-notched female lobsters varied across regions and years with no particular patterns during 2009-2019 (Table 4-2). In 2019, the percentage of female lobsters in the catch that were v-notched was 15-16 % for all regions combined. The highest percentages of V-notched females were recorded from the West and South East coasts.

Table 4-2. Percentage of female lobsters, between 87-127 m, V-notched by year and region (North West: Co. Donegal, Mayo, Sligo; West: Co. Clare, Galway; South West: Co. Kerry, Cork; South East: Co. Wexford, Waterford; East: Co. Dublin, Louth, Wicklow). Source: Marine Institute Observer data 2009-2019.

Location	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
All areas	13.76%	8.59%	10.55%	11.98%	14.15%	13.25%	12.29%	7.44%	15.64%	9.77%	15.61%
East	-	-	23.75%	-	11.59%	6.08%	5%	1.63%	3.56%	0	-
South East	20.89%	11.92%	8.11%	9.22%	13.45%	20.40%	8.87%	7.39%	18.43%	4.63%	16.25%
South West	14.71%	5.22%	8.65%	11.63%	6.82%	8.18%	1.33%	12.19%	12.59%	1.92%	15.42%
West	8.11%	12.49%	14.19%	15.94%	23.82%	21.88%	23.25%	14.86%	29.45%	17.26%	16.11%
North West	11.48%	4.97%	6.28%	10.26%	8.41%	0%	28.49%	0%	4.61%	9%	0%

4.5.2.1 Relative reproductive potential of V-notched lobsters

The reproductive potential (RP) for a given size class of lobsters is the product of the number of lobsters in the size class, the probability of maturity, the spawning frequency and the size related fecundity.

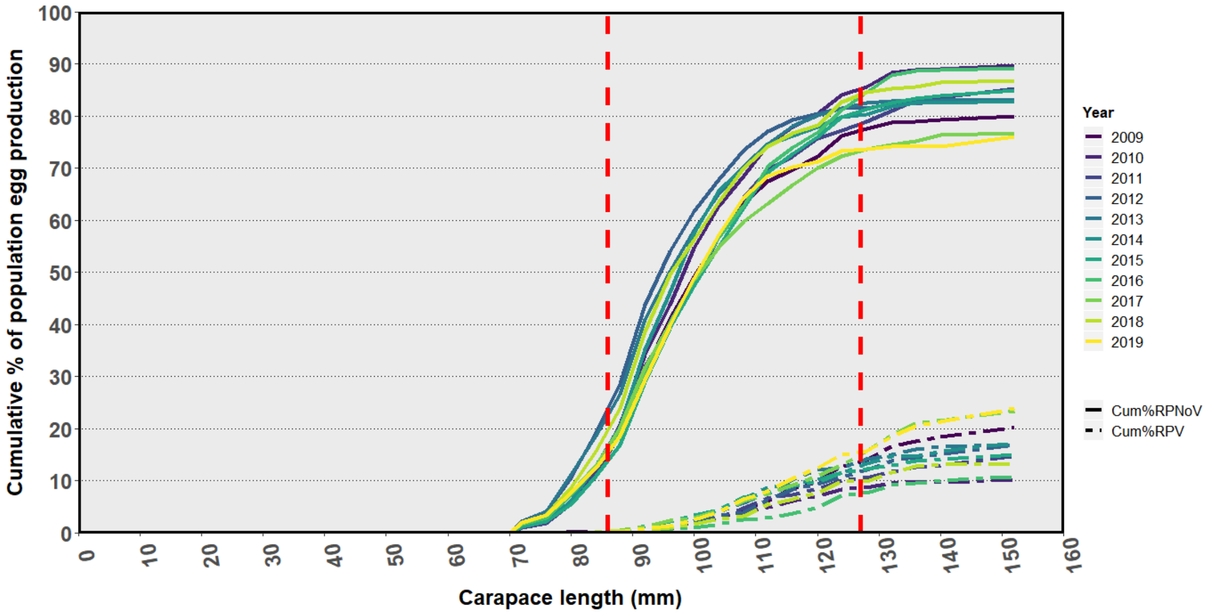


Figure 5. Cumulative distribution of reproductive potential (RP) across size classes of V-notched and non-V-notched lobsters all regions combined. Source: Marine Institute Observer data 2009-2019.

Between 60-70 % of the RP comprised of non-notched lobsters between 87-127 mm during 2009-2019 (Figure 5 and Figure 6a). For non-notched lobsters above 127 mm the RP remained stable through the time series between 2-4 %. Reproductive potential of v-notched lobsters, between 87-127 mm, ranged from 10-15 %, reaching maximum values in 2017 and 2019 (Figure 6). Reproductive potential in V-notched lobsters above 127 mm was historically between 2-4 % but increased in 2017 and 2019 to approximately 8 %. The minimum landings size regulation protects a further 10-20 % of the reproductive potential.

In 2019, 60 % of the reproductive potential consisted of legal lobsters between 87-127 mm, 16 % included v-notched lobsters between 87-127 mm, 13% of RP was protected by the MLS and a further 11 % was found within lobsters above the MaxLS. Seventy-two percent of the lobsters above the

MaxLS were also V-notched. A combination of the MLS and MaxLS technical measures, protects 24 % of current reproductive potential and V-notching protects a further 16 % (Figure 5 and Figure 6a).

There is regional and annual variability in the % of RP within each of the stock components described above; <87 mm, 87-127 mm, >127 mm and v-notched or non-notched (Figure 6b). There is high variability in the % of RP in v-notched lobsters regionally. The West and South East regions tend to have higher proportions of RP protected in V-notched lobsters than other areas (Figure 6b).

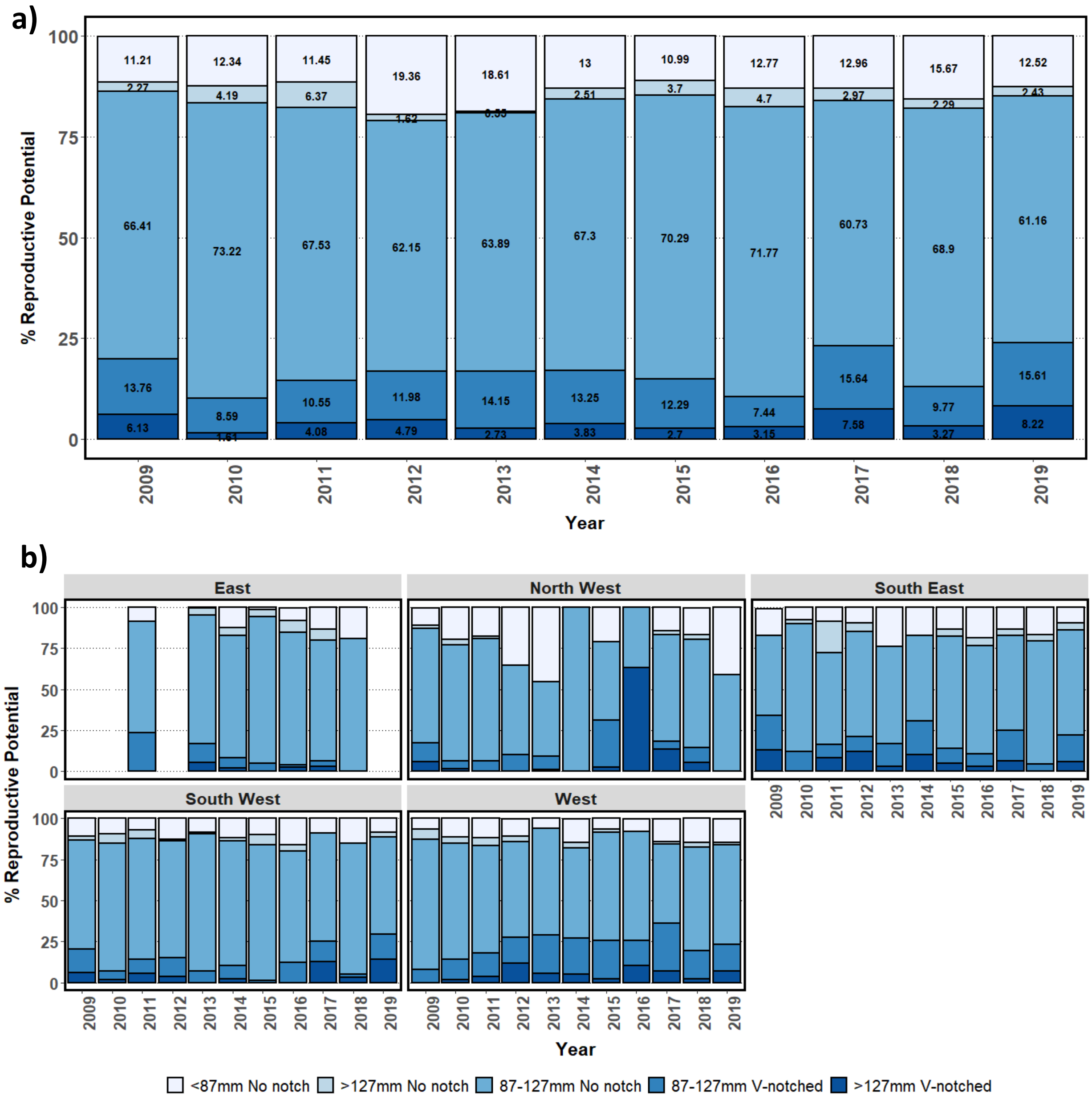


Figure 6. Summary of the distribution of the % reproductive potential in lobster stocks conserved by v-notching, minimum size and maximum size measures for a) All regions combined and b) Across regions. Source: Marine Institute Observer data 2010-2019.

4.5.3 Catch rates

4.5.3.1 Annual trends

The SVP data for targeted lobster fishing includes between 400,000-800,000 pot hauls and catches greater than 200,000 lobsters per annum (Figure 7).

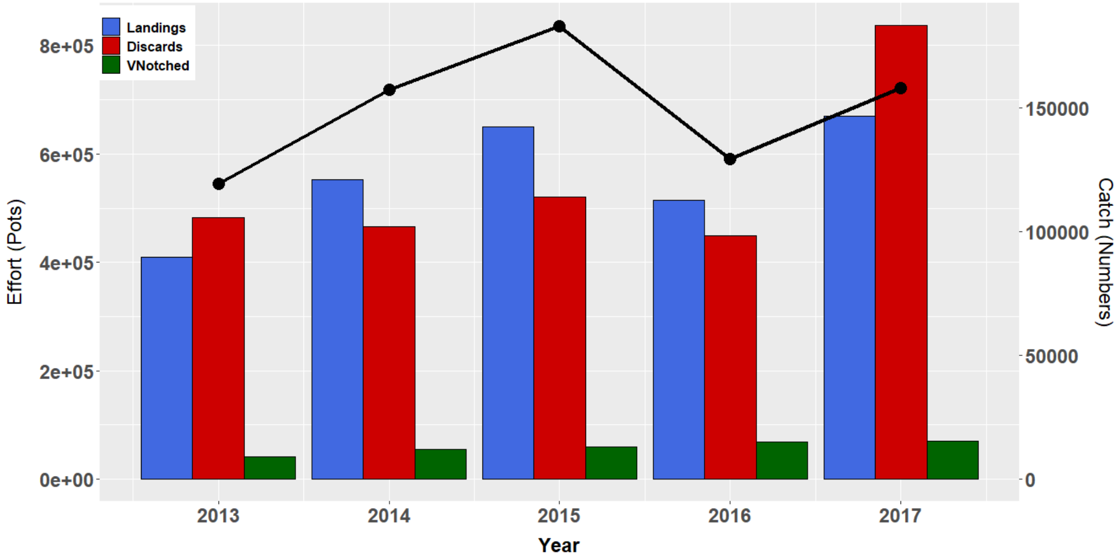


Figure 7. Annual landings, discards, v-notched discarded, effort and total catch (solid line) of lobsters reported by SVP vessels 2013-2017 (Effort units' reference: e.g.: 8e+05 = 80,000).

Landings per unit of effort (LPUE), reported from the SVP data showed a decrease from 2013 to 2015 and an increase from 2015 to 2017 to 20 Lobsters/100 pots (Figure 8). LPUE trends, from MI observer data, declined from 2015 to 2016, in contrast to the trends of the SVP programme, and increased in 2017 to approximately 30 lobsters per 100 pots.

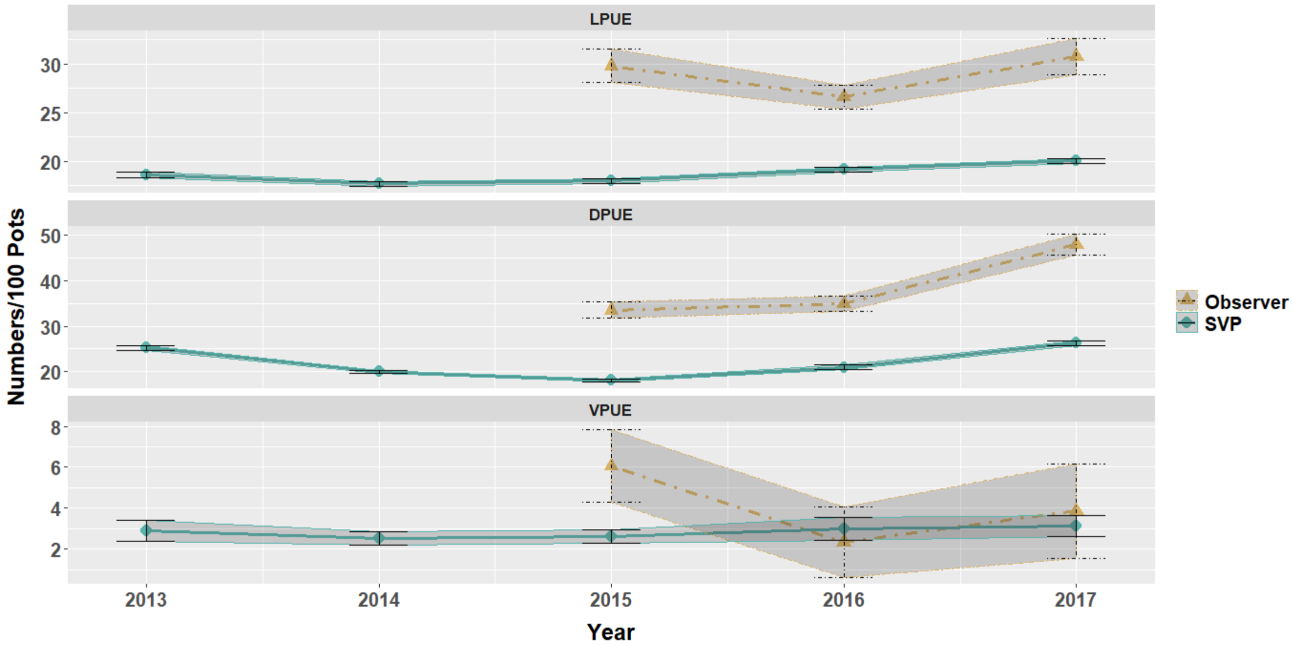


Figure 8. Annual mean landings (LPUE), discards (DPUE) and V-notched (VPUE) Lobsters per unit of effort (100 Pots) for the SVP (2013-2017) and MI Observer programme (2015-2017).

LPUE across counties, in the SVP data, was highly variable (Figure 9). Reliability of these estimates are dependent not only on the sample size but also on how representative the SVP vessel is of the fleet operating in the region.

The Discards per unit effort (DPUE) from the MI observer data was approximately 15 Lobsters per 100 pots higher than reported in SVP and shows increasing patterns in the last two years across counties (Figure 8 and Figure 9). Discard rates were higher than landed rates in 2013, 2016 and 2017 in the SVP programme and for all years of the MI observer programme. DPUE's were higher than LPUE's in Co. Clare, Co. Donegal, Co. Mayo, Co. Wexford from 2013-2017 in the SVP data. V-notched per unit effort (VPUE) rates were stable in the SVP programme at approximately 3 Lobsters per 100 pots (Figure 8). There were 9 V-Notched Lobsters per 100 pots in Sligo. VPUE patterns in the observer programme showed a decrease from 2015 to 2016, but was similar to the SVP in 2016-2017.

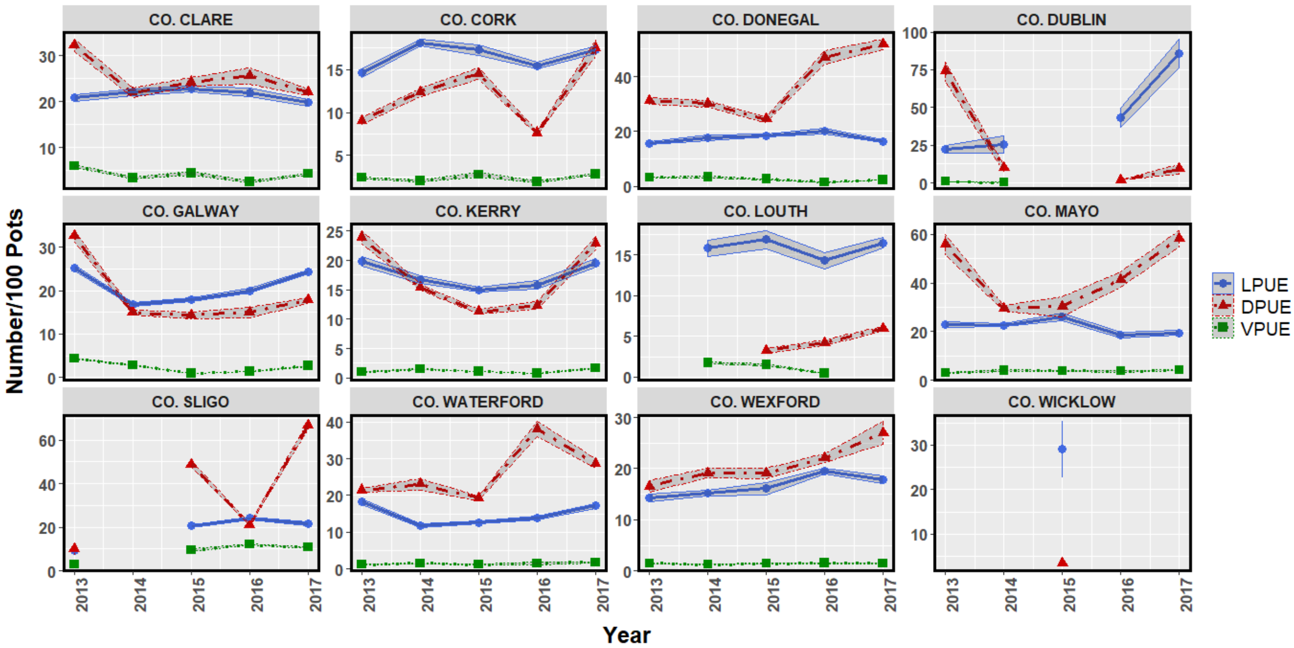
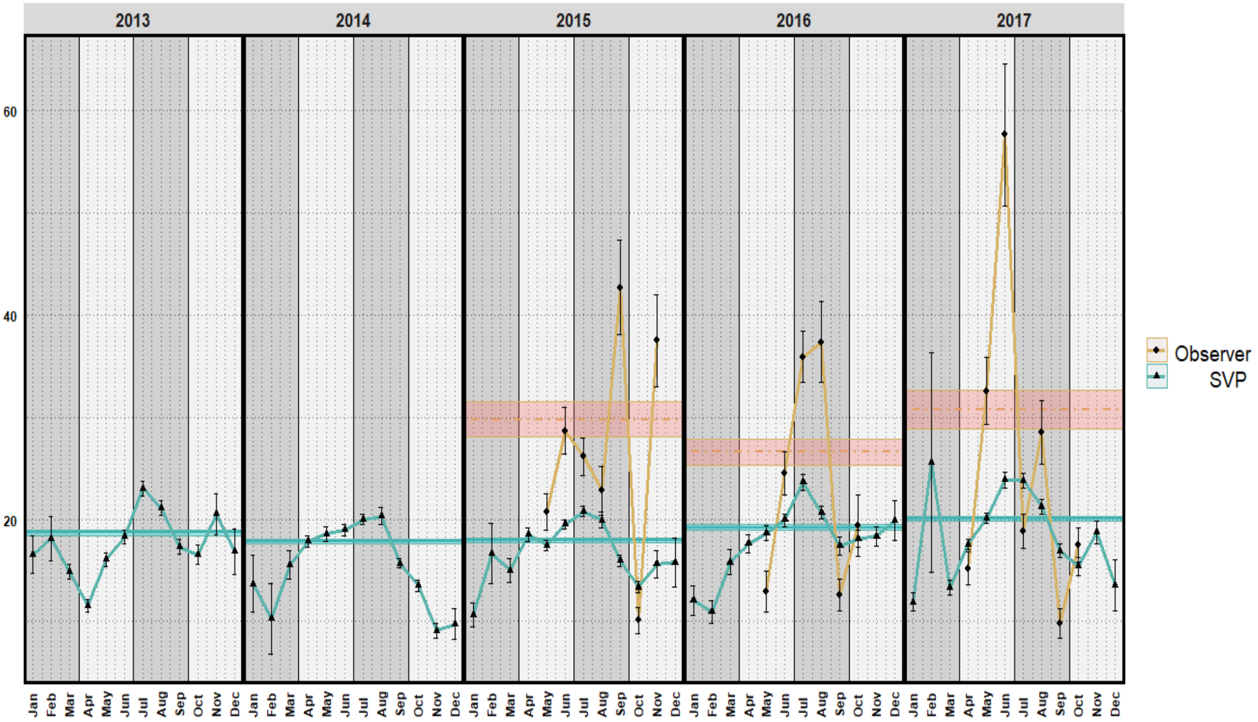


Figure 9. Annual mean landings (LPUE), discards (DPUE) and V-notched (VPUE) Lobsters per unit of effort (100 Pots) for the SVP program 2013-2017 across counties. Vertical scales vary by County.

4.5.3.2 Seasonal trends in catch rates

Monthly averages of LPUE and DPUE show clear seasonal patterns with increasing catches generally occurring during quarters 2 and 3 from both SVP and Observer programmes (Figure 10 and Figure 11).

a)



b)

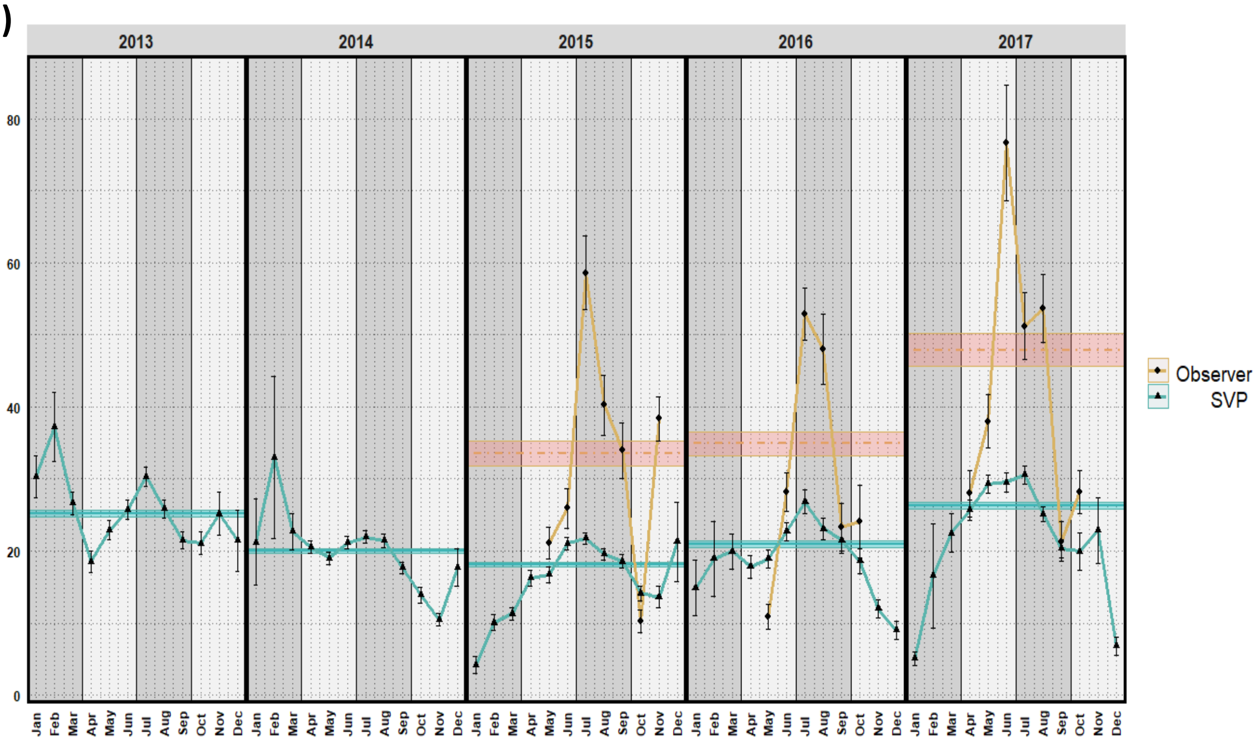


Figure 10. Monthly mean landings (LPUE) and discards (DPUE) of Lobsters per unit of effort (100 Pots) for the Sentinel Vessel and Observer programmes 2013-2017. Horizontal lines in each year show annual means (Green for SVP and red for Observer Program). Year quarters are shaded grey and white.

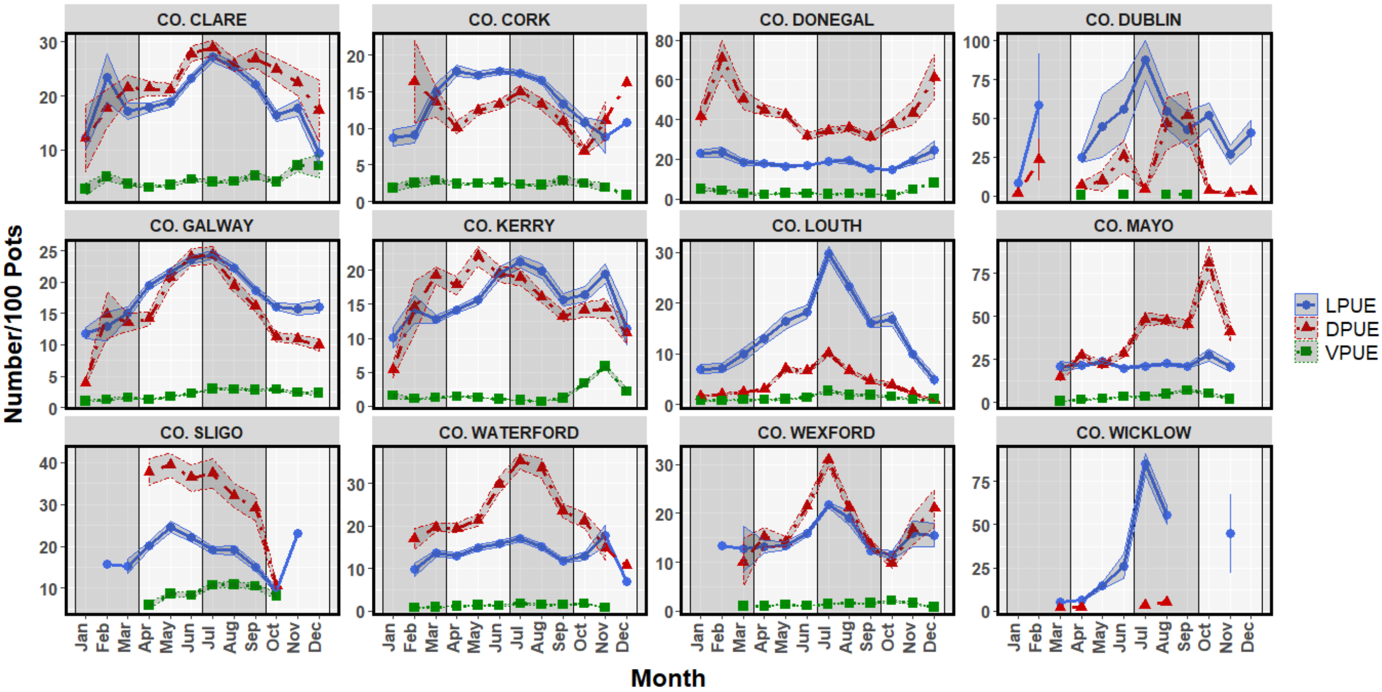


Figure 11. Monthly mean landings (LPUE), discards (DPUE) and V-notched (VPUE) Lobsters per unit of effort (100 Pots) for the Sentinel Vessel Programme 2013-2017 across counties. Year quarters are shaded grey and white.

5 Brown crab (*Cancer pagurus*)

5.1 Management advice

The crab fishery is managed by a minimum landing size of 140 mm.

A decrease in landing per unit effort (LPUE) was observed in most areas in 2016 and 2017 compared to previous years. The exceptions were Counties Clare, Cork and Wexford. Mean LPUE for trips targeting crab in 2017 was 1.6 Kg/Pot from Sentinel Vessel Programme (SVP) data and 1.2 Kg/Pot from MI Observer Programme data. The highest estimates of LPUE throughout the time series were recorded from Counties Clare, Kerry and Mayo.

LPUE for vessels targeting lobster and capturing crab as bycatch remained stable throughout the time series. Mean annual LPUE in 2017 was 0.5 Kg/Pot from SVP data and 0.3 Kg/Pot from Observer data and was well below the catch rates from trips targeting crab, indicating a clear targeting intention by Skippers.

The modal size of crab landed from both port-processor and observer data in recent years was stable at 150-160 mm indicating significant high grading above the minimum landing size of 130 mm (prior to 2019) and 140 mm (from 2019 to date).

Landings peaked in 2016 and 2017 at 11,000 tonnes and fell to just over 8,500 tonnes in 2018 and 2019. Fishing effort increased in the period 2017-2019 (anecdotal) and was driven by exceptionally high market prices in the Asian market. The decline in LPUE and total landings as effort increases most likely indicates growth overfishing. Growth at modal landing sizes of 150-160 mm is slow, given that most of the growth has already occurred, and the rate of fishing needs to be consistent with the rate at which crabs can grow into these size classes if catch performance is to be maintained. Years of high landings (2017-2018) are likely to be followed by years of lower landings (as observed in 2018-2019) where the rate of removal exceeds the rate of replacement by growth. Effort or landings control is needed to achieve this stability.

5.2 Issues relevant to the assessment of the crab fishery

Assessments based on length data and biological parameters can provide estimates of fishing mortality (exploitation status). However, there are a number of assumptions underlying these methods and estimates are highly sensitive to growth rate parameters which are poorly estimated.

Landings per unit effort indicators are compromised by unknown grading practice on vessels and it is important that discard data is also available to construct the total catch if these data are to reflect changes in stock abundance. Given recent increases in fishing effort gear saturation effects may also be reducing catch per unit effort (CPUE). Standardising the nominal catch rate data for these and other effects is therefore important and is in progress.

As the data on catch rates reported here shows there are high levels of variation between vessels, areas, seasons and years it is difficult to identify patterns (stable or otherwise). An increase in the quantity of catch and effort data reported for the fishery is needed to ensure absence of bias and increase precision and to take into account geographic and seasonal effects on catch performance.

5.3 Management units

Targeted fisheries for brown crab in Ireland developed during the 1960s. The fishery developed off Malin Head in Donegal and along the Donegal coast and, to a lesser extent, on the south coast during the 1970s. The Malin Head fishery accounted for 25 % of national landings during the 1980s. The offshore fishery developed in 1990 and by the mid-1990s had fully explored the distribution of brown crab on the Malin Shelf. This stock, which extends from Donegal to the edge of the continental shelf, is the largest stock fished by Irish vessels. Crab stocks off the southwest and southeast coasts are exploited mainly by Irish vessels <13 m in length inside 12 nm.

ICES (WG Crab) has identified stock units for the purpose of assessment (Figure 12). On the Irish coast these units are identified from tag return data, distribution of fishing activity and larval distribution.

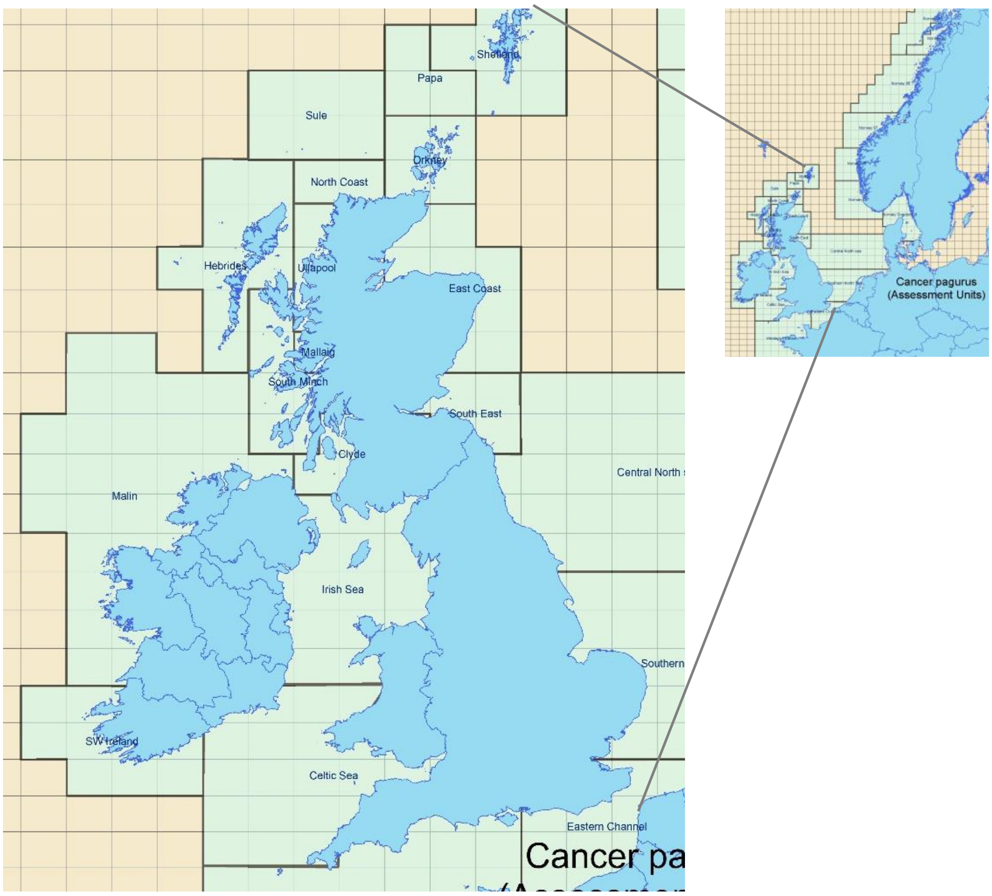


Figure 12. ICES stock assessment units for Brown crab.

5.4 Management measures

Crab are managed using a minimum landing size of 140 mm. There is a limit on fleet kwdays at sea for vessels over 15 m in ICES Area VI and for vessels over 10 m in the Biological Sensitive Area (BSA) in ICES Area VII. This is ineffective in controlling fishing effort.

5.5 Stock status indicators

Two independent sources of data were analysed in this report. Sentinel Vessel Programme (SVP) self-sampling data from 2013-2017 and Marine Institute (MI) observer data from 2015-2019. SVP catch rate data from 2018 and 2019 was not included in this analysis as it is still being validated. Before 2015, observer trips targeting crab were very limited and thus removed. Table 5-1 shows the number of SVP trips and observer hauls targeting crab and where crab was captured as by-catch per year.

Table 5-1. Number of SVP trips and Observer hauls per year were Crab was targeted or bycatch. *includes both target and by-catch hauls.

Target Species	Sampling Type	2013	2014	2015	2016	2017	2018	2019
Brown Crab	**SVP (trips)**	1,319	1,304	1,171	1,597	1,379	-	-
	Observer (hauls)	-	-	207	80	238	**450***	**290***
Lobsters with crab by-catch	**SVP (trips)**	1,518	1,536	1,775	1,113	1,781	-	-
	Observer (hauls)	-	-	388	293	514		

Landings and discards of brown crab from the SVP are reported in different units, i.e. kilograms, boxes, trays and numbers. The data for this report are recorded in kilograms. A box of landings was assumed to be approximately 35 Kg based on previous reports from observer trips, while a box of discards was converted to 40 Kg. One tray was assumed to represent half a box. Numbers were converted to weights after calculating the modal size for landings (150-160 mm) and discards (130 mm) (Figure 14) obtained from port-processor and observer trips, respectively and applying a Length-Weight relationship ($\mathbf{W}=2.5*10^{-4}\mathbf{L}^{2.89}$) estimated from the port-processor database.

5.5.1 Size distribution indicators

Histograms and density plots of length distributions from the observer data show a relatively stable length distribution and similar modal sizes in both landings and discards for the time series (Figure 14). The modal size of crab ranged between 150-160 mm across years indicating significant high grading above the minimum landing size of 130mm (prior to 2019) and 140 mm in 2019.

5.5.2 Catch rates

5.5.2.1 Landings in SVP programme

Total landings, discards and number of pots for vessels targeting crab participating in the Sentinel Vessel Programme over the time series are shown in Figure 13. Landings and effort reported by SVP vessels reached a peak of approximately 1,700 tonnes in 2015. From 2015 onwards, the total number of pots deployed increased whereas landings decreased to 1,400 tonnes in 2016 and 1,300 tonnes in 2017. Discard estimates follow the same declining pattern as the landings, reaching a minimum in 2017 at approximately 250 tonnes.

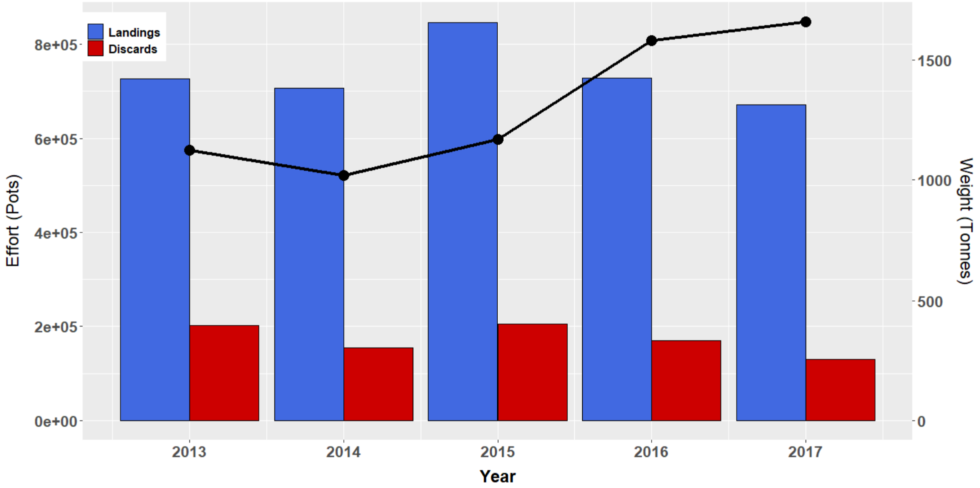


Figure 13: Landings and discards (tonnes) of crab and total effort (number of pots) reported in the Sentinel Vessel Programme 2013-2017. Solid line; fishing effort (pot hauls) from the SVP data. (Effort unit's reference: e.g.: 8e+05 = 80,000).

5.5.2.2 Annual trends

LPUE was stable in the SVP data in 2013-2015 with an annual mean of approximately 2.6 Kg per pot but decreased in 2016 and again in 2017 (approximately 1.6 Kg/Pot from SVP data and approximately 1.1Kg/Pot from MI observer data) (Figure 15). This decreasing trend was observed in most counties, except for Clare, Cork and Wexford (Figure 16). The observer programme data is less precise due to less data being available (Table 5-1) (Figure 15). DPUE also declined but less so than targeted LPUE. LPUE and DPUE of crab caught in gear targeting lobster were relatively stable but significantly lower than in gear targeting crab as expected.

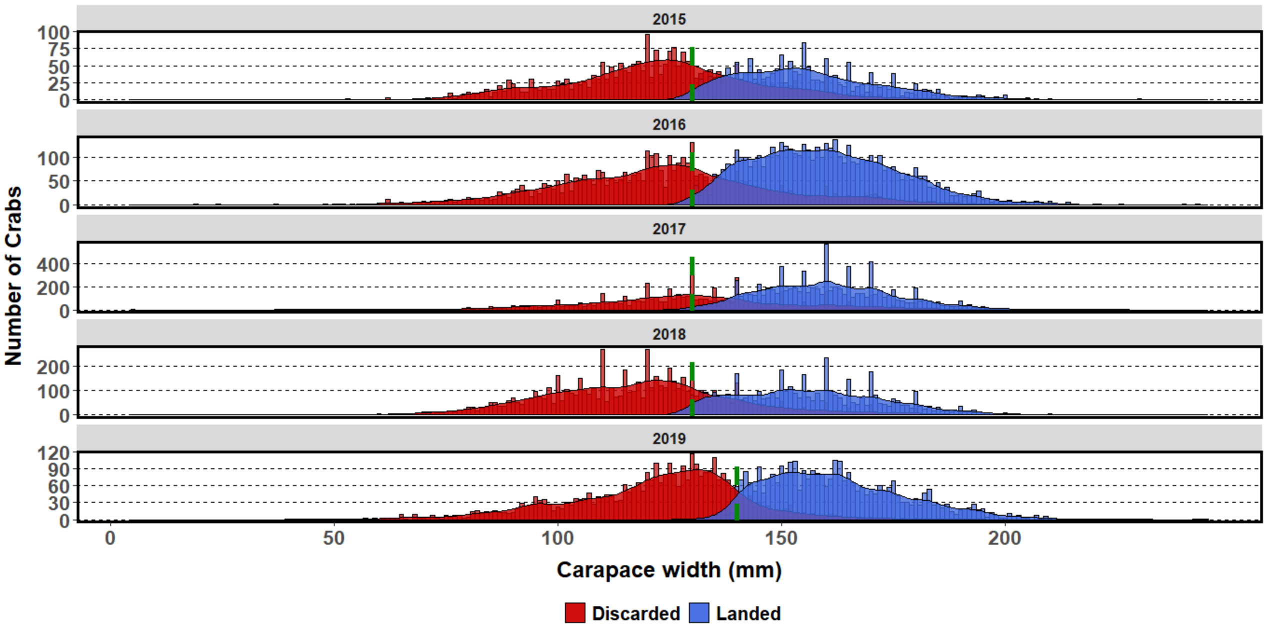


Figure 14. Size distribution (1 mm size bins) of crab from the MI observer programme between 2015-2019. Green dashed line shows the 130 mm (2015-2018) and 140 mm (2019) minimum landing size. Note the scale of the y-axis varies.

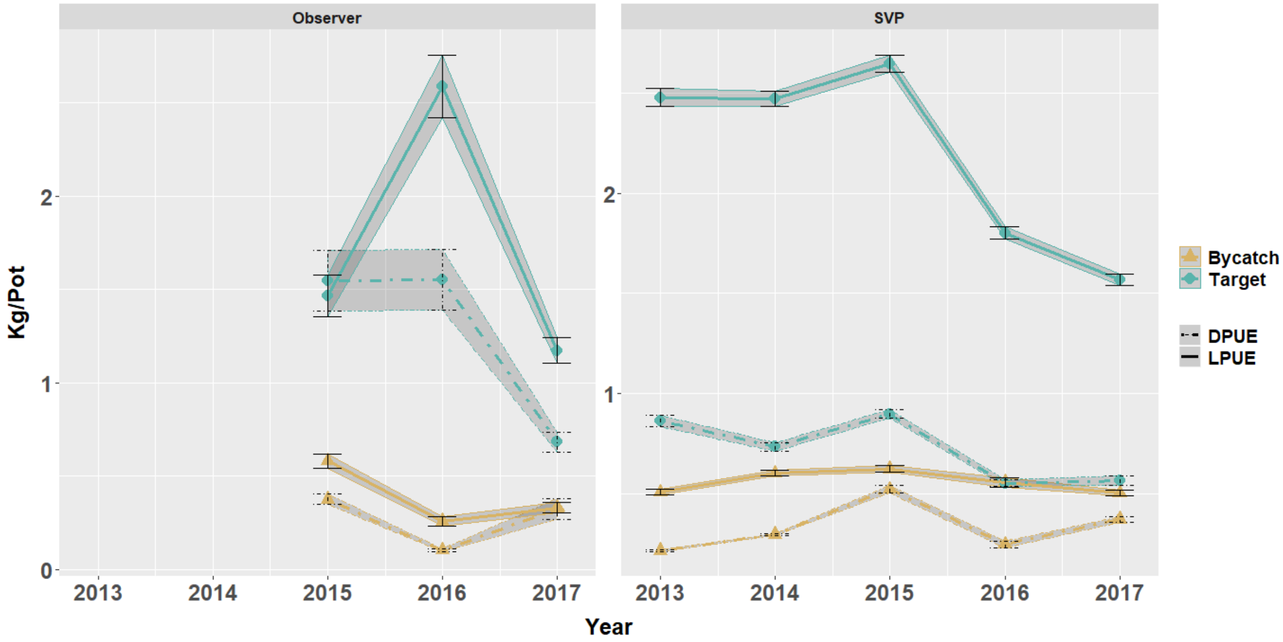


Figure 15: Annual mean LPUE and DPUE (Kg/pot) with standard error for SVP and Observer programme data from trips both targeting brown crab and where brown crab is being caught as by-catch from 2013-2017.

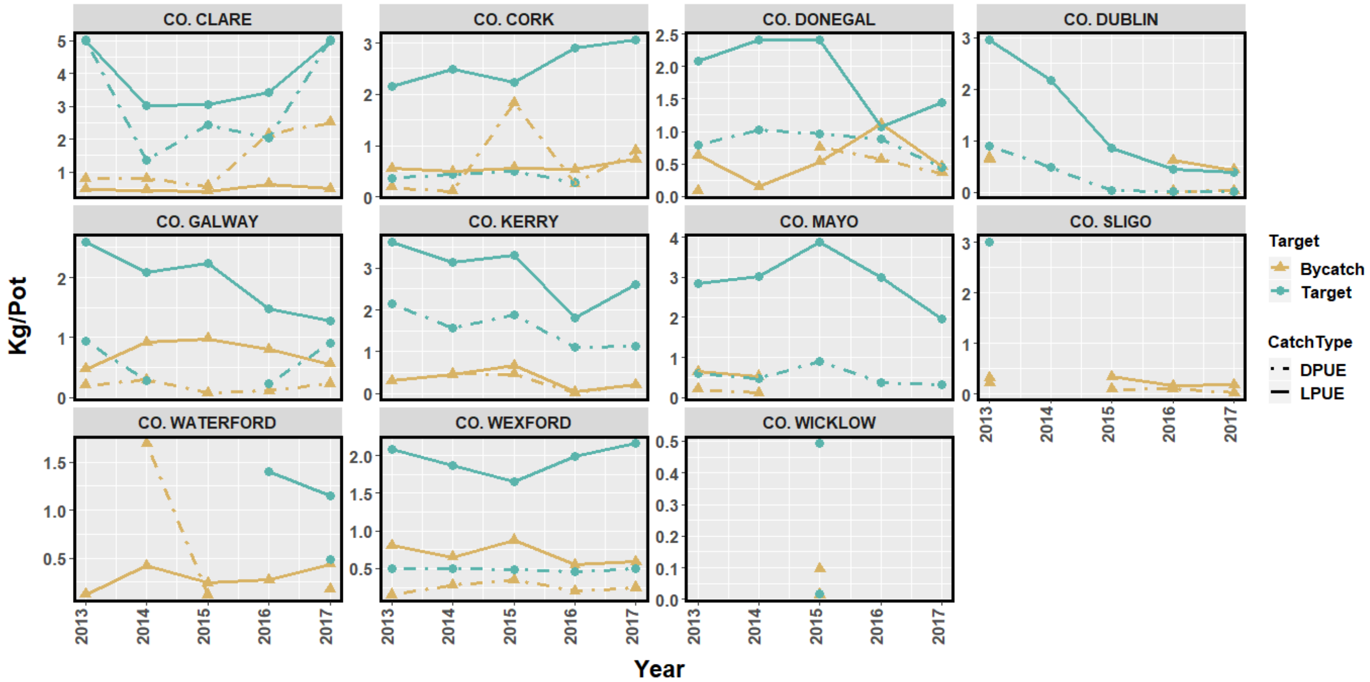


Figure 16: Annual mean LPUE and DPUE (Kg/pot) by county for SVP trips both targeting crab and where crab is caught as bycatch 2013-2017.

SVP data georeferenced to ICES statistical rectangle Figure 17 showed decreases in mean LPUE in most areas with the exception of Counties Clare and Wexford. DPUE's were below 1Kg/Pot in most areas, except in Co. Clare in 2017 where high discards rates were observed (Figure 17).

Vessels which have participated in the Sentinel Vessel Programme every year and have targeted brown crab show different trends (Figure 18). The general decrease in both LPUE and DPUE in the SVP fleet (see Figure 15) did not occur in all vessels. Vessels showing stable or increasing trends throughout the time series are located in Counties Clare and Wexford.

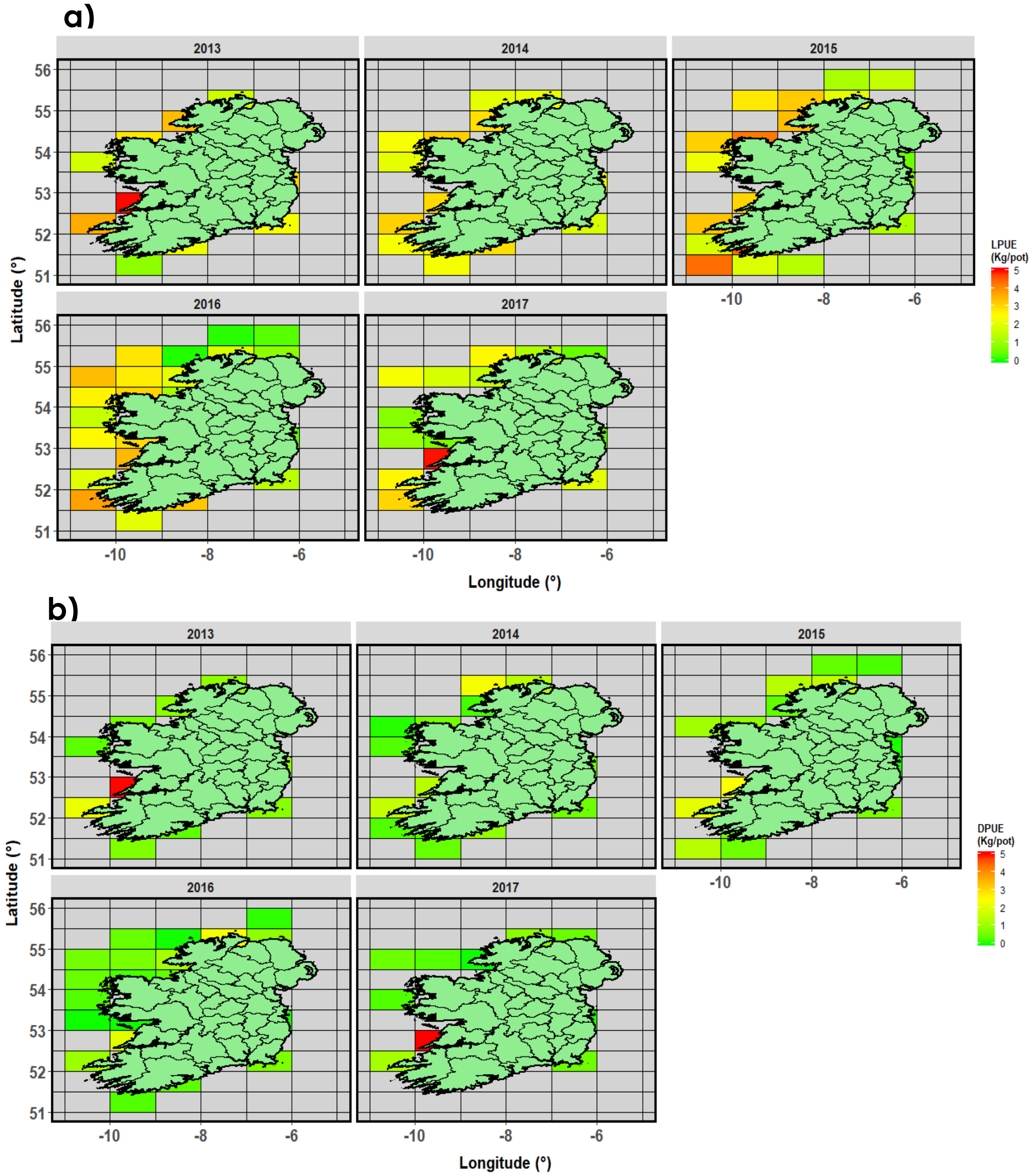


Figure 17. Annual mean a) LPUE and b) DPUE (Kg/pot) by ICES statistical rectangle for vessels participating in the Sentinel Vessel Programme targeting crab.

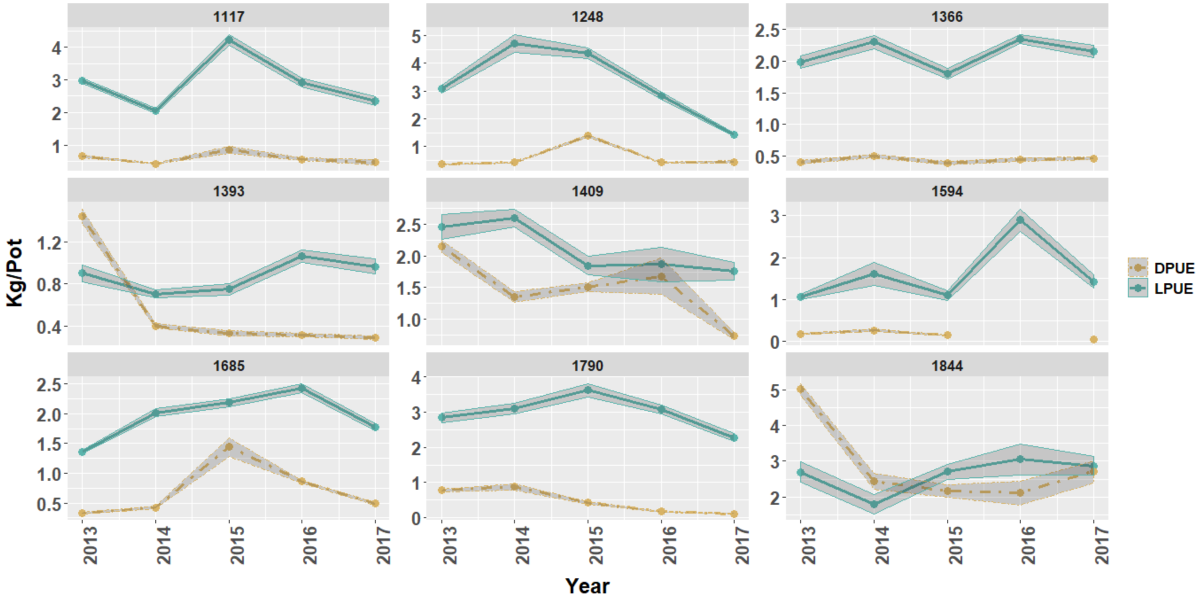


Figure 18. Annual mean LPUE and DPUE (Kg/pot) from individual vessels targeting crab that have participated in the Sentinel Vessel Programme since 2013. Vessel ID's were generated randomly.

5.5.2.3 Seasonal trends

LPUEs targeting crab show peaks in Quarter 3 and early Quarter 4 from both SVP and Observer programme data (Figure 19a, Figure 20a and Figure 21) with the exception of 2014 and 2015 where LPUE peaked in Quarters 1 and 2 (Figure 19a). LPUE's from the Sentinel Vessel Programme data of by-caught brown crab peaked in Quarter 4 (Figure 19a), particularly in Counties Clare, Donegal, Galway and Waterford (Figure 21). These trends differ from the Observer programme data (Figure 20a). DPUE trends tended to follow LPUE trends from both sampling programmes (Figure 19b, Figure 20b and Figure 21).

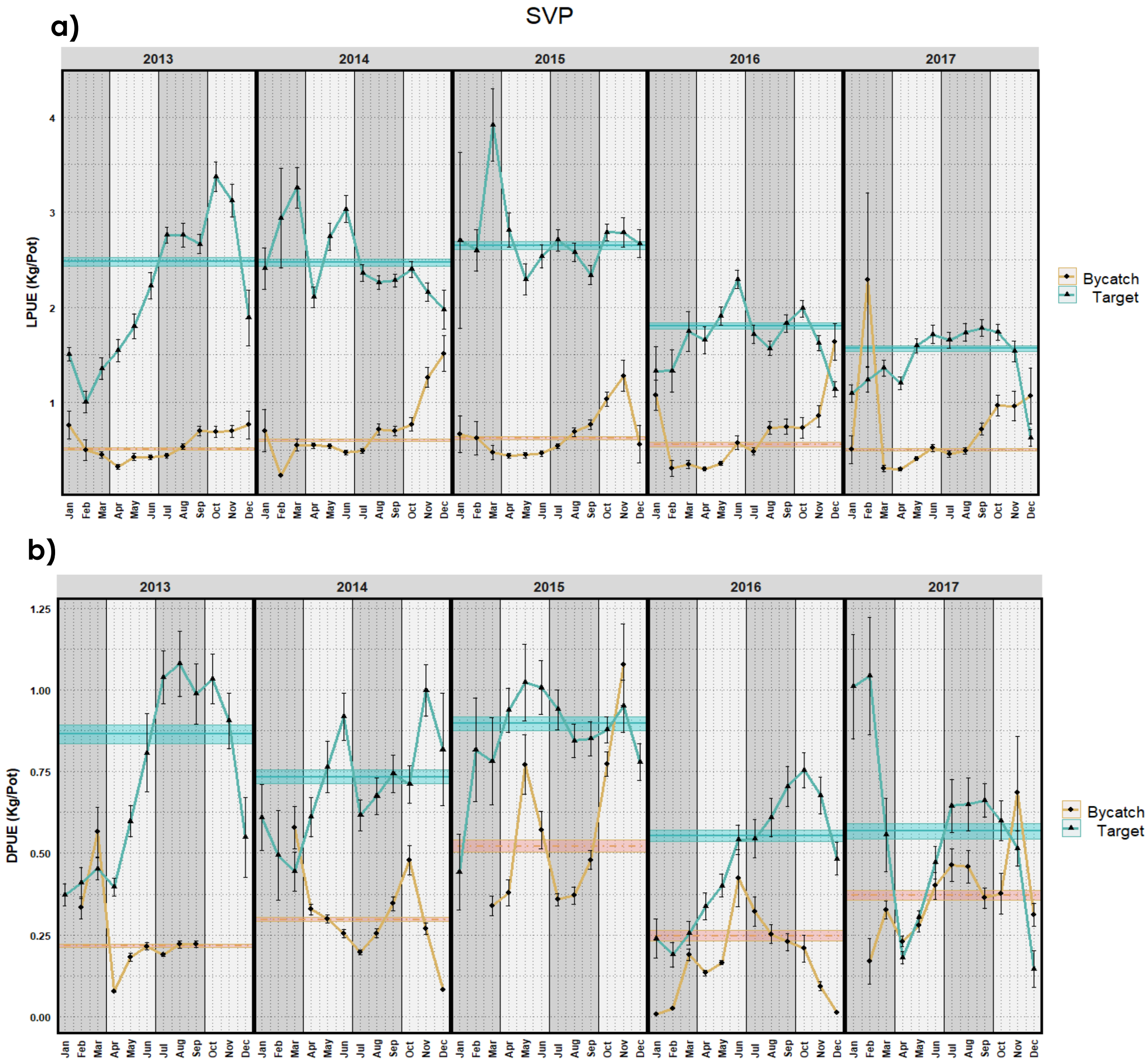


Figure 19. Monthly mean a) LPUE and b) DPUE (Kg/pot) with standard errors for SVP in trips where crab was targeted (blue) and captured as bycatch (brown). Horizontal lines in each year show annual means. Year quarters are shaded grey and white.

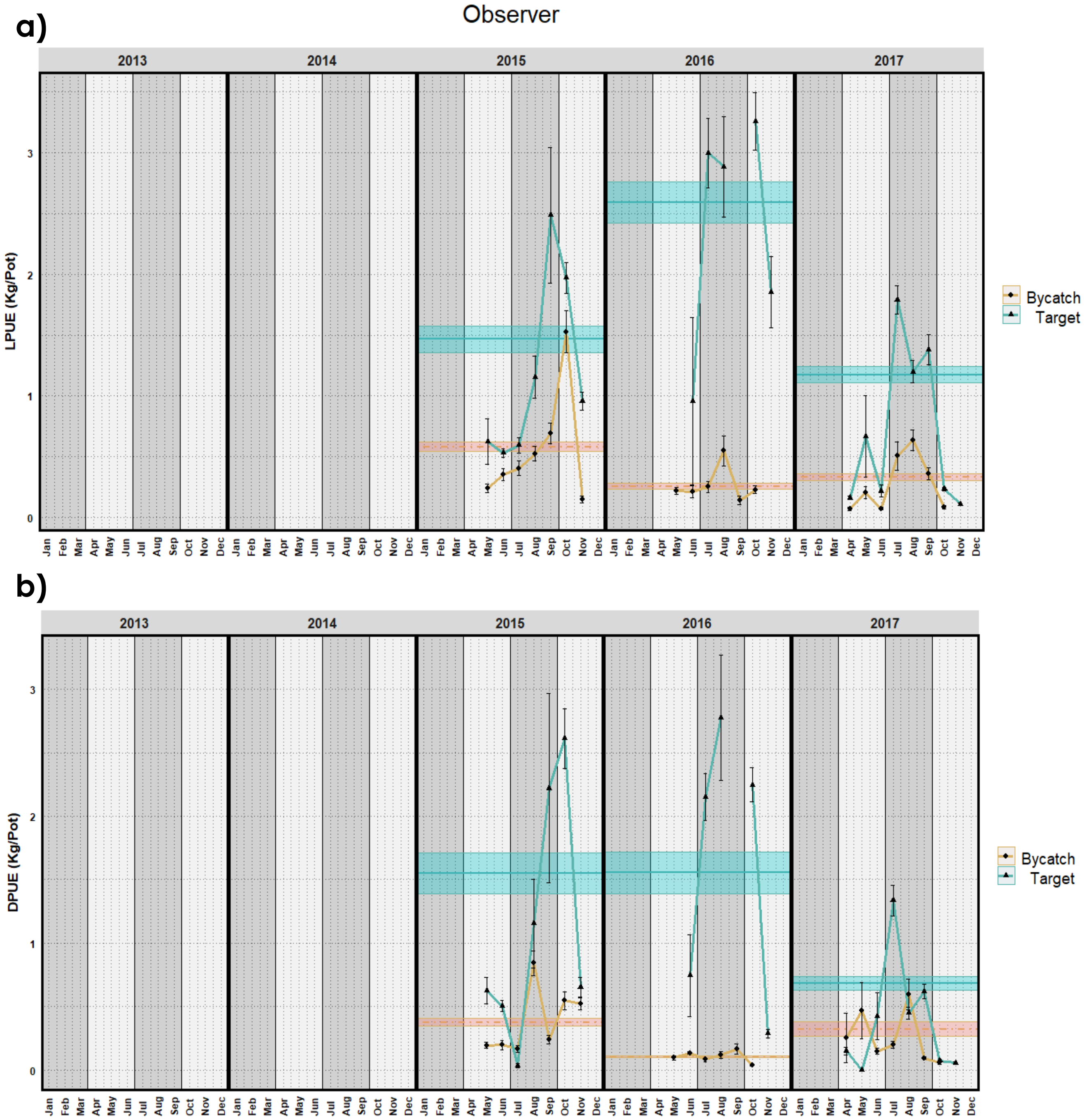


Figure 20. Monthly mean a) LPUE and b) DPUE (Kg/pot) with standard errors for observer programme in trips where brown crab was targeted (blue) and captured as bycatch (brown). Horizontal lines in each year show annual means. Year quarters are shaded grey and white.

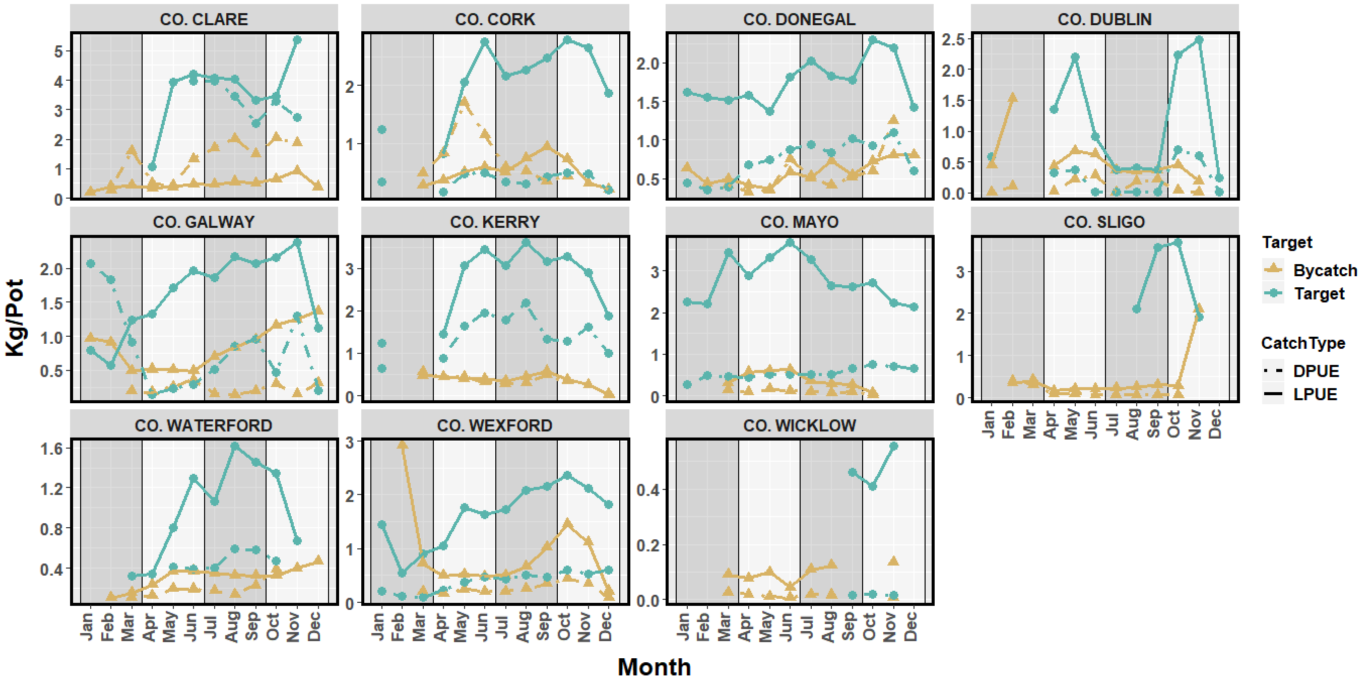


Figure 21. Monthly means in LPUE and DPUE for SVP trips targeting crab and capturing it as bycatch. Year quarters are shaded grey and white.

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

6.1 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, Inisbofin, Killary and Ballinakill Bay in 2019 based on advisory 15 % harvest rates. These smaller scale fisheries operated successfully in 2019 under voluntary management plans.

Landings in the North Irish Sea declined between 2015-2019. The number of vessels in the fishery increased from 49 in 2015 to 73 in 2016 and 2017 and declined to 56 in 2019. All indicators (daily landings per vessel, catch per hour) show significant and persistent declines over time. Surveys in 2017-2019 indicated a biomass of 6,158, 3,978 and 4,832 tonnes, respectively, and an approximate annual exploitation rate of 10-15 %. Large size classes are being depleted and the fishery is increasingly reliant on small and less valuable clams due to growth overfishing. 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.

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 biomass increased significantly between 2017 and 2019 surveys. A TAC of approximately 600 tonnes is recommended.

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 advice. In the north Irish sea bivalve fauna caught as by-catch is being depleted and may result in more general effects on seafloor fauna that could reduce prey for the Common Scoter (a species of diving seaduck). Given the high number of vessels in the North Irish Sea fishery there is a risk of disturbance and displacement of Common Scoter from preferred habitat.

6.2 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*.

Ecosystem effects of the fishery on the seafloor and on seabirds which feed on benthic bivalves needs to be considered in the assessment advice.

6.3 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.

6.4 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 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 January 1st 2016) with a prohibition on landing on Sundays (SI 588/2015). The fishery is closed by voluntary agreement 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).

6.5 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 22). Vessel monitoring systems data (10 minute reporting frequency) shows fishing activity from Dundalk Bay to Malahide and at Lambay Island. 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. The majority of fishing effort in 2018 and 2019 was in Dundalk Bay and south of Clogherhead at Gormanstown.

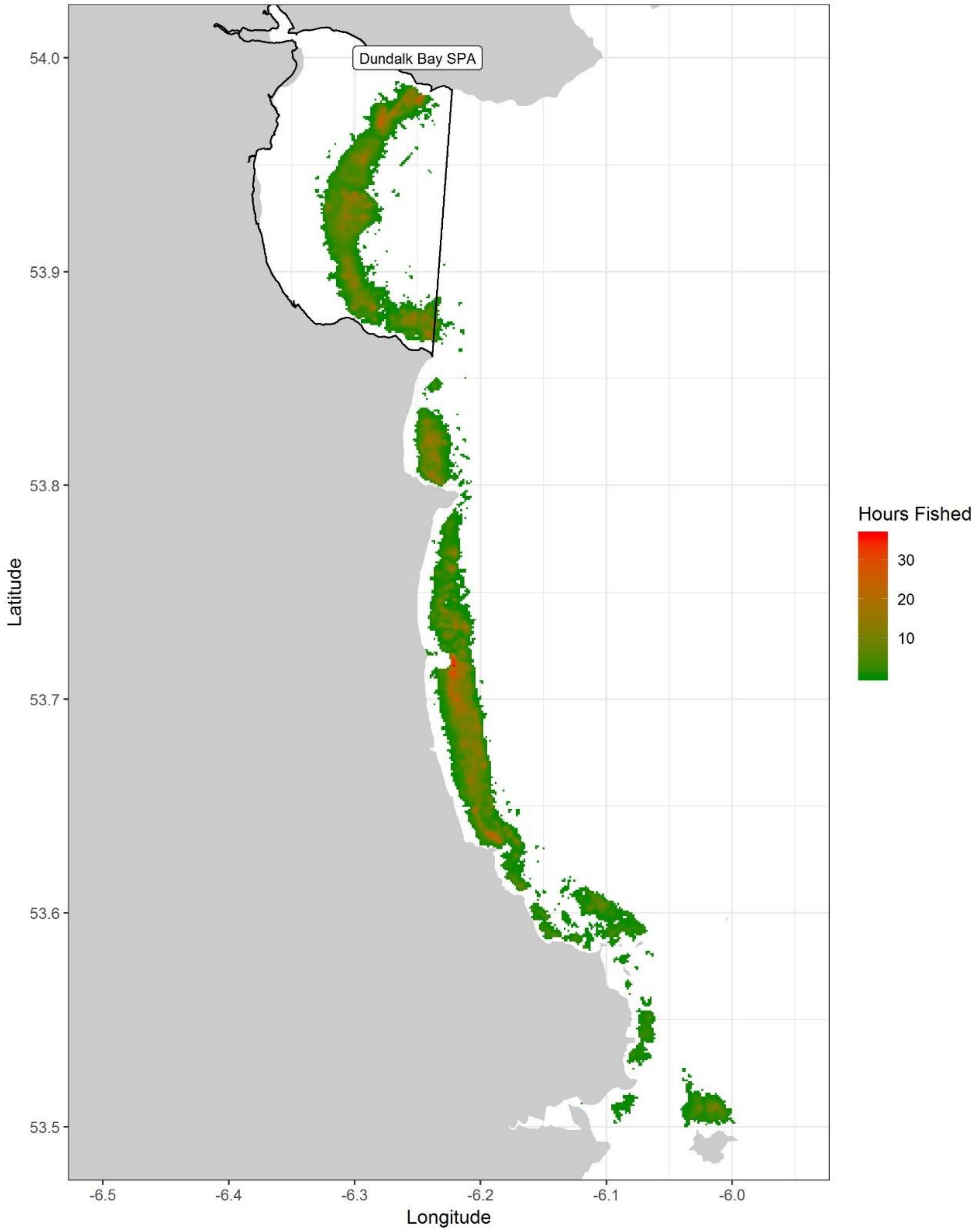


Figure 22. Distribution of fishing effort by vessels fishing for razor clams in the north Irish Sea during the period July 2018 to June 2019.

6.5.1 Landings

The North Irish Sea (NIS) Razor Clam (*Ensis siliqua*) fishery began in 1998. The fishery developed quickly due to high quality (size) of clams in the Gormanstown bed which attracted premium prices compared to other *Ensis* species fished in Europe. There may have been 50 vessels involved in the fishery by 1999. Effort declined in 2002-2003 due to pipe laying in the sea area off Gormanstown. Post 2003 beds at Malahide, Skerries and south Dundalk Bay were being fished in addition to the Gormanstown bed. Market demand was limited at this time.

Landings increased from 274 tonnes in 2012 to 1,064 tonnes in 2015. This was paralleled by an increase in the number of vessels from 21 to 49. The number of vessels peaked in 2016 and 2017 at 73 but landings declined from 2015 to 2019. The number of vessels declined to 56 in 2019. Total landings for 2019 was 533 tonnes (Figure 23).

The Dundalk Bay and Gormanstown production areas accounted for 619 of 716 tonnes of landings in the north Irish Sea in 2018 and 488 of 533 tonnes (91%) in 2019 (Figure 24).

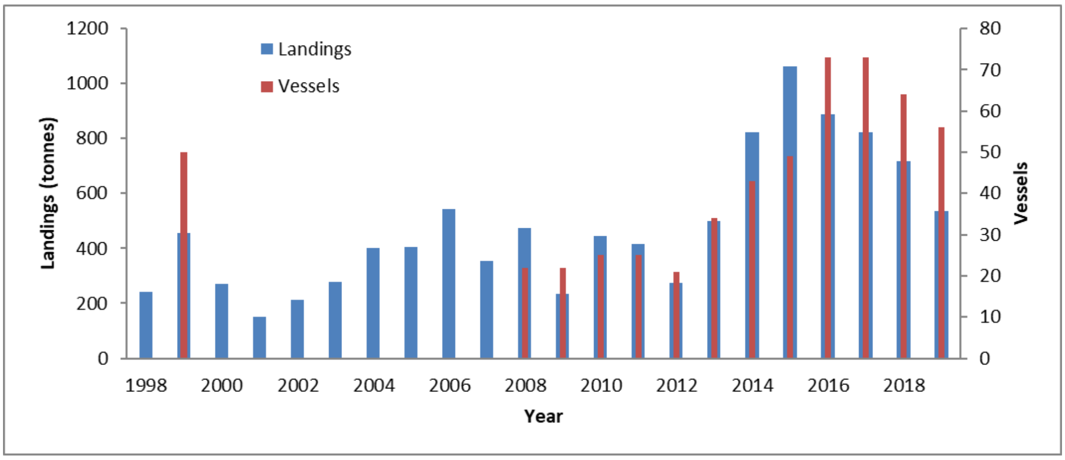


Figure 23. Annual landings of *Ensis siliqua* in the north Irish Sea (NIS) 1998-2018 sourced from SFPA logbook, shellfish gatherers data and sales notes. The number of vessels landing razor clams each year is shown for 1999 and from 2008 to 2018.

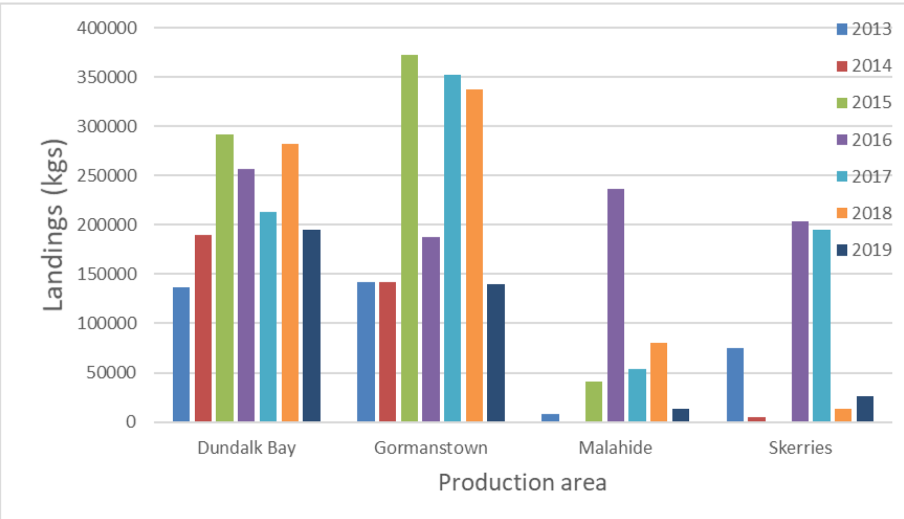


Figure 24. Landings per classified bivalve production area 2013-2019.

6.5.2 Survey design 2019

A survey encompassing all of the areas which are commercially fished for Razor clams was completed in the north Irish Sea in June 2019. The survey follows the design in 2017 and 2018 which used an iVMS grid to allocate survey effort; iVMS activity is seen as a proxy for the abundance of razor clams. 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 allocated to each of 5 survey vessels. 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 iVMS effort. The survey was mostly completed over a 3-5 day period, depending on area and vessel.

Biomass at each station was estimated as the product of density (number of individuals caught per meter squared towed area) and 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 method preserves the spatial structure in the biomass, as described by variograms, which modelled the spatial autocorrelation and spatial structure in the survey data.

6.5.3 Survey Results 2019

6.5.3.1 Size distribution

The dominant modal shell size in 2017 was 130 mm with a second 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 25). 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. Modal size in 2019 was 150 mm. There was no evidence of significant recruitment into the stock in 2018 or 2019 and changes in size in those years are due to growth and mortality (Figure 26).

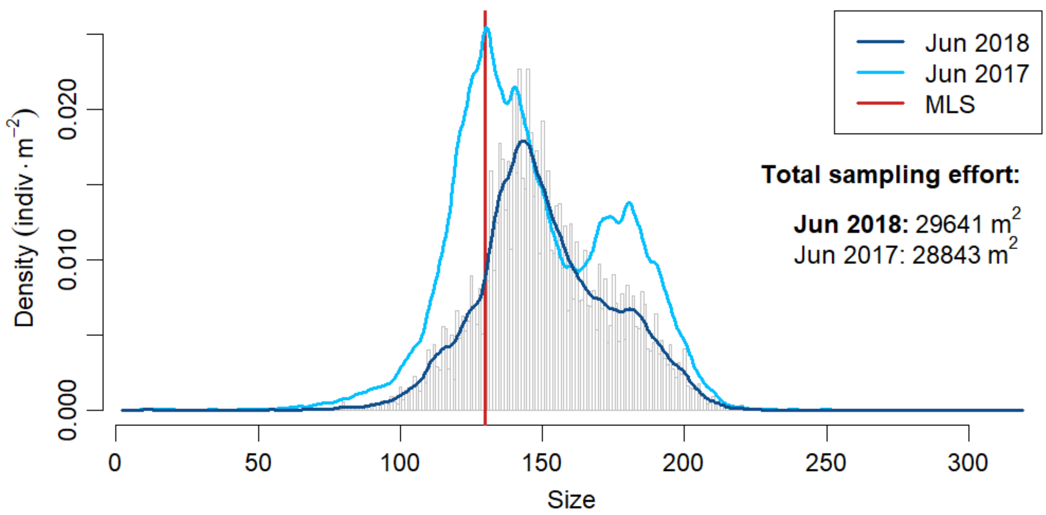


Figure 25. Size distribution of razor clams in 2017-2018 survey data.

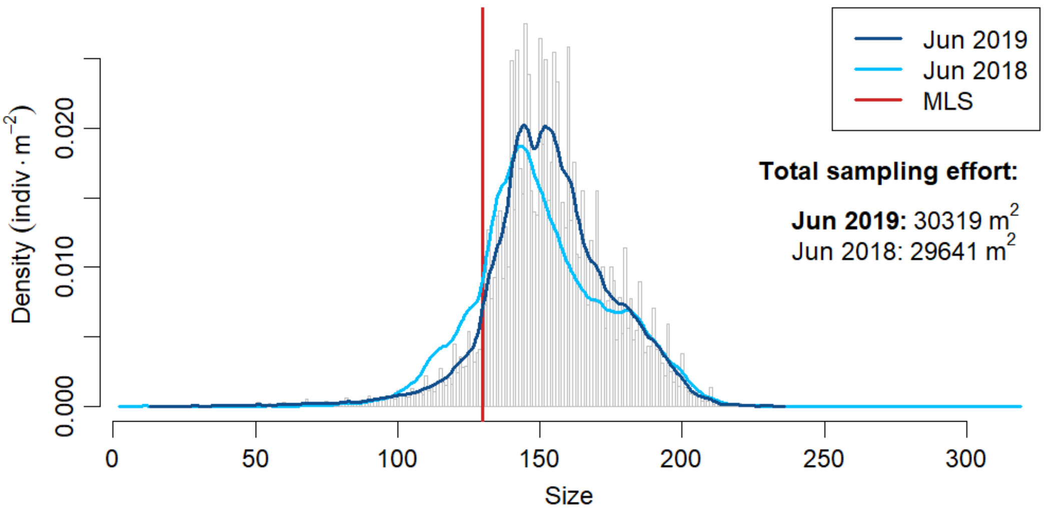


Figure 26. Size distribution of razor clams from 2018-2019 survey data.

6.5.3.2 Biomass

Total biomass of razor clams in the survey area was 6,158, 3,978 and 4,813 tonnes in 2017-2019, respectively (Table 6-1, Figure 27). The proportion of total biomass over 150 mm shell length increased from 60 % in 2017 to 66 % in 2018 and 71 % in 2019 indicating a progression in size due to growth and general absence of recruitment (Table 6-1).

Razor clams occur from north Dundalk Bay south to Malahide and at Lambay in depths ranging from chart datum to 15 m. The seaward extent of the survey (and the fishery) is limited by the functioning of the fishing gear. From 2017-2019 highest biomass (kgs.m^{-2}) generally occurred off Skerries, Balbriggan and Malahide and east of the Boyne estuary (Figure 28).

Table 6-1. Biomass of razor clams in the North Irish Sea in 2017-2019.

Year	Variable	Biomass (tonnes)	Simulated 95% CLs	
			Lower 95% CL	Upper 95% CL
2017	Biomass all size classes	6158.5	7026.4	8069.8
2017	Biomass >130mm	5320.7	6040.4	6918.6
2017	Biomass >150mm	3693.1	4263.0	4840.8
2018	Biomass all size classes	3978.6	4384.2	5075.3
2018	Biomass >130mm	3691.4	4101.9	4745.8
2018	Biomass >150mm	2609.8	2862.5	3271.8
2019	Biomass all size classes	4813.8	5381.9	6243.8
2019	Biomass >130mm	**4591.8**	5174.1	6071.6
2019	Biomass >150mm	3435.5	3898.4	4514.5

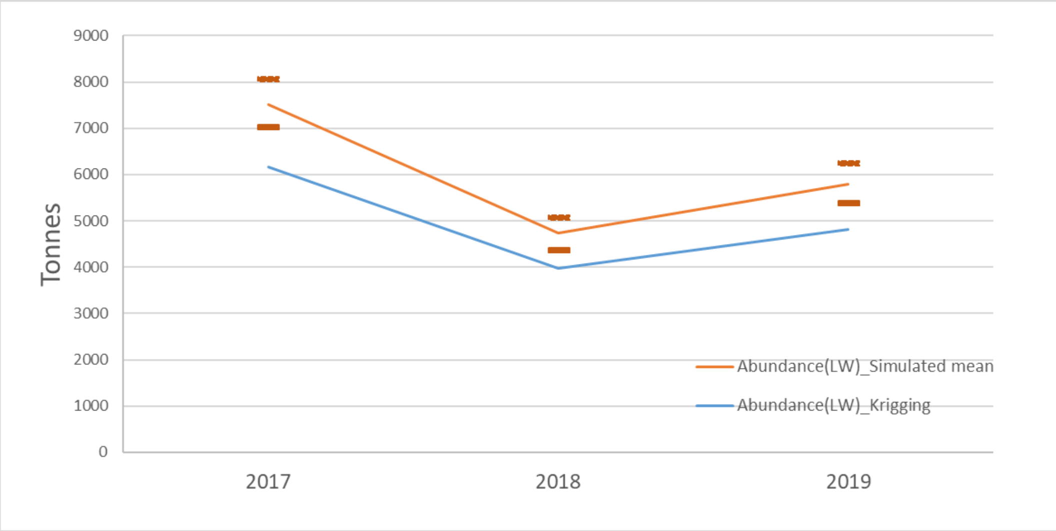


Figure 27. Trends in stock biomass of razor clams 2017-2019 in the north Irish Sea.

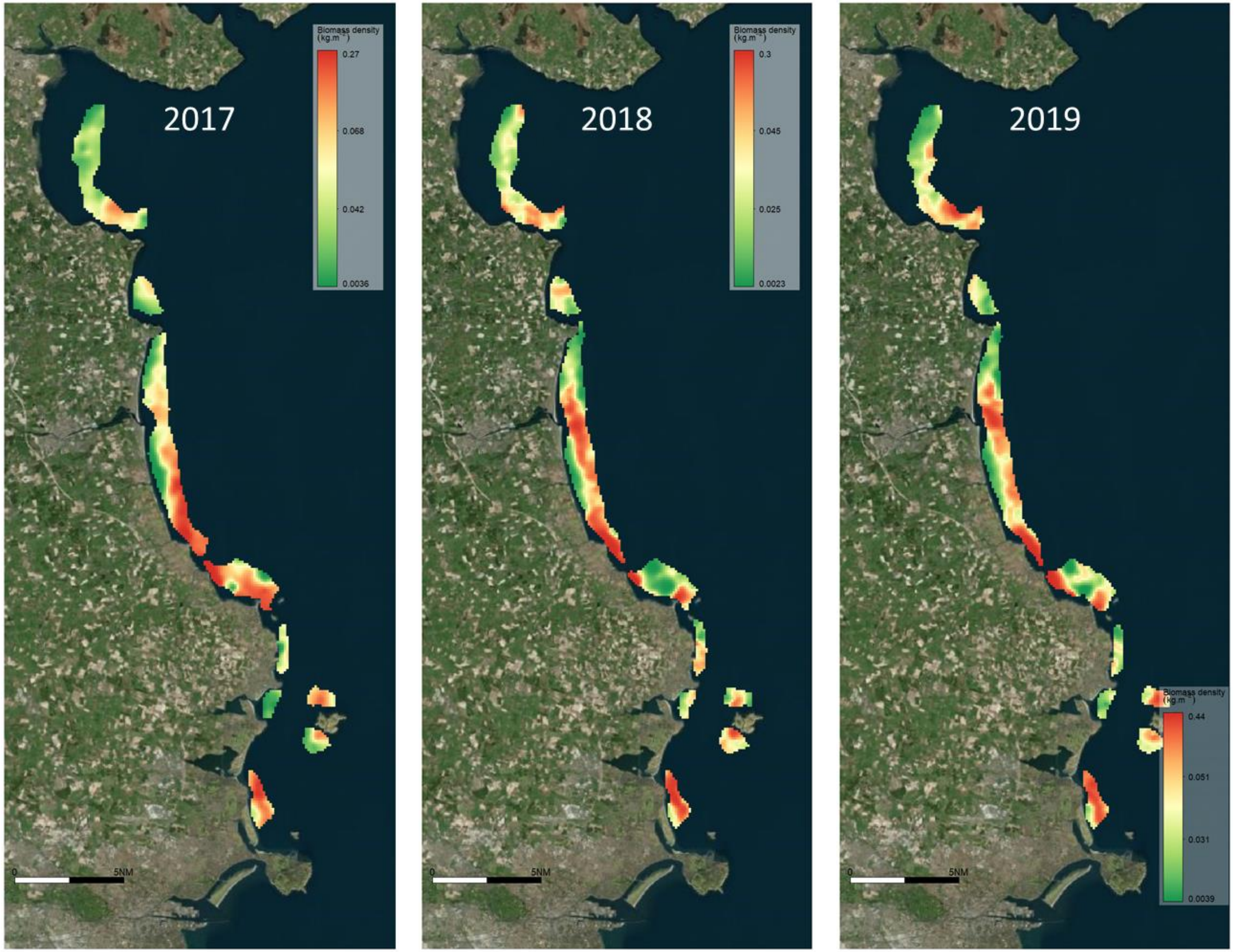


Figure 28. Distribution of biomass of razor clams in the north Irish Sea June 2017 to 2019.

6.5.4 Stock biomass indicators

Stock biomass indicators (LPUE kgs.day^{-1}, LPUE kgs.hr^{-1}) were estimated from data on consignments to buyers in 2013-2019 and from sentinel vessels 2011-2019. 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 600 kgs.

Daily consignments (kgs.day^{-1}) declined from 300 kgs.day^{-1} in early 2013 to 200 kgs.day^{-1} by end of 2016 (Figure 29). In 2018 and 2019 average daily landings in some months were less than 150 kgs.day^{-1} and average daily landings per month were less than 200 kgs in 2018 and 2019.

The sentinel vessel data provides a more precise indicator of stock biomass in LPUE per hour of dredging. This indicator declined from 23kg.hr^{-1} in 2011 to 11kg.hr^{-1} in 2019 (Figure 30) and declined on average by 0.12kgs.hr^{-1}.month^{-1} during that period.

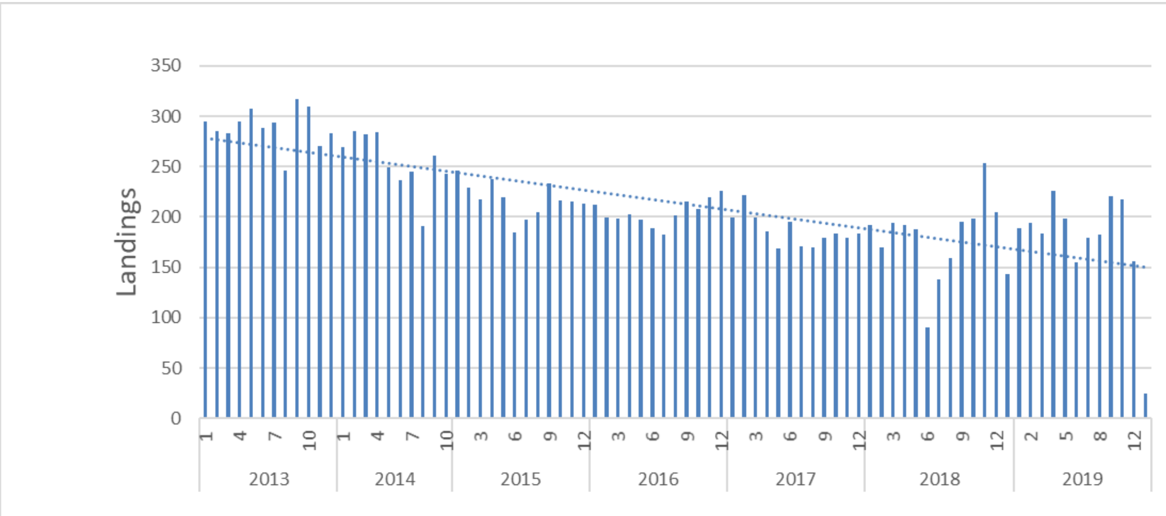


Figure 29. Average daily consignments (kgs) per month recorded in gatherers dockets 2013-2019 showing a rate of decline of 2 kg per day per month in consignment volume. Source: SFPA.

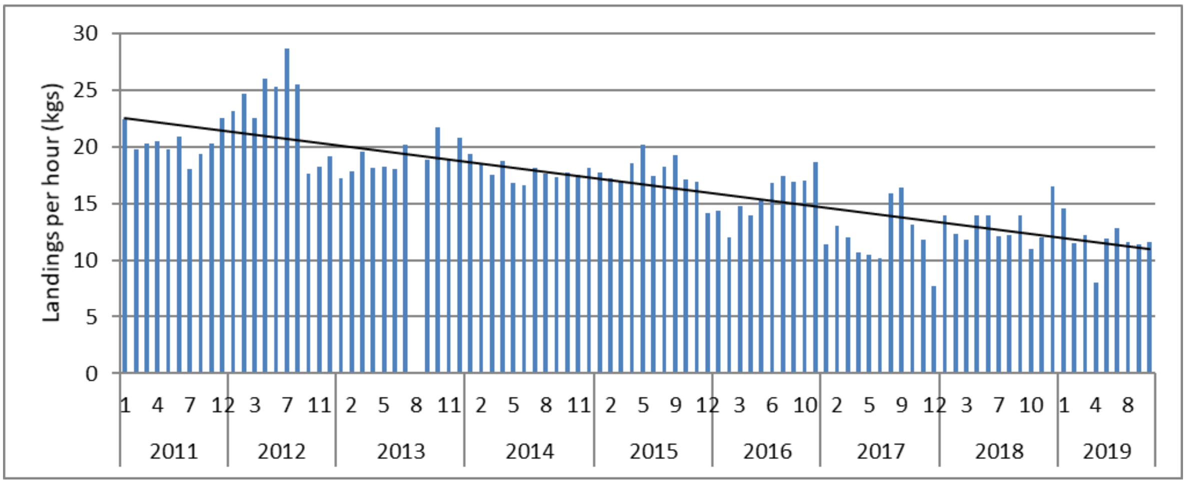


Figure 30. Monthly trends in landings per day by sentinel vessels reporting between 2011 and 2019.

6.5.5 Catch advice

The DCAC model estimates the sustainable catch by penalizing the average yearly landings based on the observed depletion in abundances indices. If there is no depletion the sustainable catch is simply the average of the historic catch! The base formula only gives a single estimate, with no confidence interval. A Bayesian implementation of the DCAC model, using life history based methods to estimate the B_{msy}/B_o and F_{msy}/M ratios, was developed to take into account most of the known sources of uncertainty and to provide a confidence interval of the sustainable catch. The model was fitted to landing per unit effort (LPUEs) estimated from logbooks, and diaries from 2001-2005 and 2009-2016, as well as LPUEs for the Gormanstown bed extracted from a previous study undertaken by Fahy and Gaffney in 2001 (for reference as they estimated 60 % of depletion in July 1999) (Figure 31).

The DCAC assessment suggests that the sustainable yield for Razor clams in the North Irish Sea is 360 tonnes, with a 95 % confidence interval of 301 to 409 tonnes. The actual yearly catches of about 450 tonnes between 2003-2015 and over 700-1,000 tonnes in 2015-2017 are significantly higher than the sustainable yield. Landings in 2019 were 533 tonnes.

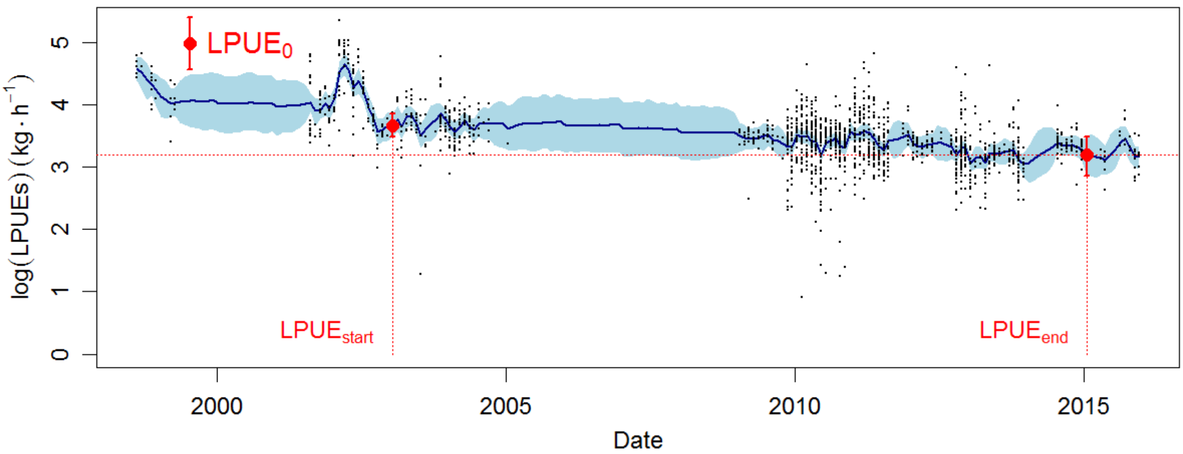


Figure 31. LPUEs fitted by the Bayesian DCAC model with a yearly trend and autocorrelation AR(1) between month (blue: mean and 95 % CI). The values retained to estimate the delta of the DCAC models are shown in red.

6.5.6 Economic viability of the fishery

Prices of Razor clams per kilogram (Table 6-2) increased from an average of €2.21 in 2010 to €7.49 in 2019. 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 peaked in 2019 owing to higher fuel prices and longer days at sea (Table 6-2). Net value of clams caught per day at sea increased from 2011-2015 and declined in 2016-2017. Strong prices reported from SVP data in 2019 increased value per day at sea.

Table 6-2. Annual trends in fuel costs, hrs at sea, price of clams, LPUE and net (of fuel) value of the catch between 2010 and 2017.

Year	Daily fuel cost	Diesel per Litre	Hrs at sea per day	Price of clams per kg	Kgs per hr at sea	Net value of daily landings	Net value per hr at sea
2010	€208	€0.65	13.2	€2.21		€599.00	
2011	€243	€0.80	17.1	€2.54	20.40	€638.00	€36.90
2012	€272	€0.92	14.2	€3.45	20.20	€669.00	€45.60
2013	€226	€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	17.90	€1,185.00	€88.00
2016	€136	€0.60	13.4	€6.20	15.40	€1,077.00	€85.00
2017	€214	€0.62	19.2	€5.90	11.70	€1,087.00	€59.00
2018	€197	€0.63	16	€5.78	13.00	€1,063.00	€62.00
2019	€302	€0.76	19.9	€7.49	12.20	€1,553.00	€74.00

6.5.7 Ecosystem effects of the fishery

The fishery may impact a number of ecosystem components in the North Irish Sea including seafloor faunal communities and sediments and also some seabirds that rely on bivalves for food and which are sensitive to disturbance by marine traffic.

6.5.7.1 Effects on surficial seafloor fauna

The razor clam dredge penetrates seafloor sediments to a depth of approximately 25 cm, disturbs significant volumes of sediment due to the use of pressurised water jets at the dredge head and leaves clear furrows on the seafloor (Figure 32). Impacts on sediments and infauna are expected due to this disturbance and long term effects will depend on the footprint of the fishery and capacity of fauna to recover.

In June 2016 a survey was undertaken from Dundalk Bay south to Balbriggan to investigate if there were differences in surficial sediments and fauna across 6 fishing intensity strata (areas receiving 0-0.167 hrs; 0.167-2 hrs; 2-5 hrs; 5-10 hrs; 10-15 hrs and 15-30hrs). The fishing intensity strata, representing a gradient of fishing intensity from effectively zero to 30 hrs per 100 m^2 grid cell, were selected by examining 6 months of iVMS data (from October 2015 to March 2016).

Table 6-3. Mean values of the diversity indices for all fauna calculated across each of the six fishing intensity strata, including the range for the Number of taxa per strata.

Strata	Number of taxa (S)		Mean Number of individuals (N)	Mean Margalef's species richness index (d)	Mean Pielou's evenness index (J')
	Mean	Range			
1	29.51	9-71	223.67	5.36	0.73
2	23.37	10-42	187.00	4.42	0.73
3	24.84	13-38	209.13	4.54	0.71
4	28.82	16-47	250.50	5.12	0.71
5	31.97	15-50	299.83	5.48	0.69
6	30.05	18-40	307.00	5.12	0.66

Following an initial decline from the lowest fishing intensity strata the mean number of taxa and overall abundance of fauna showed an overall increase from the lower effort strata to the highest effort strata (Strata 6) (Table 6-3). A significant difference between the lower effort strata (1, 2 and

3) and the higher effort strata (4, 5 and 6) in the number of species (S) and the number of individuals (N) was found.

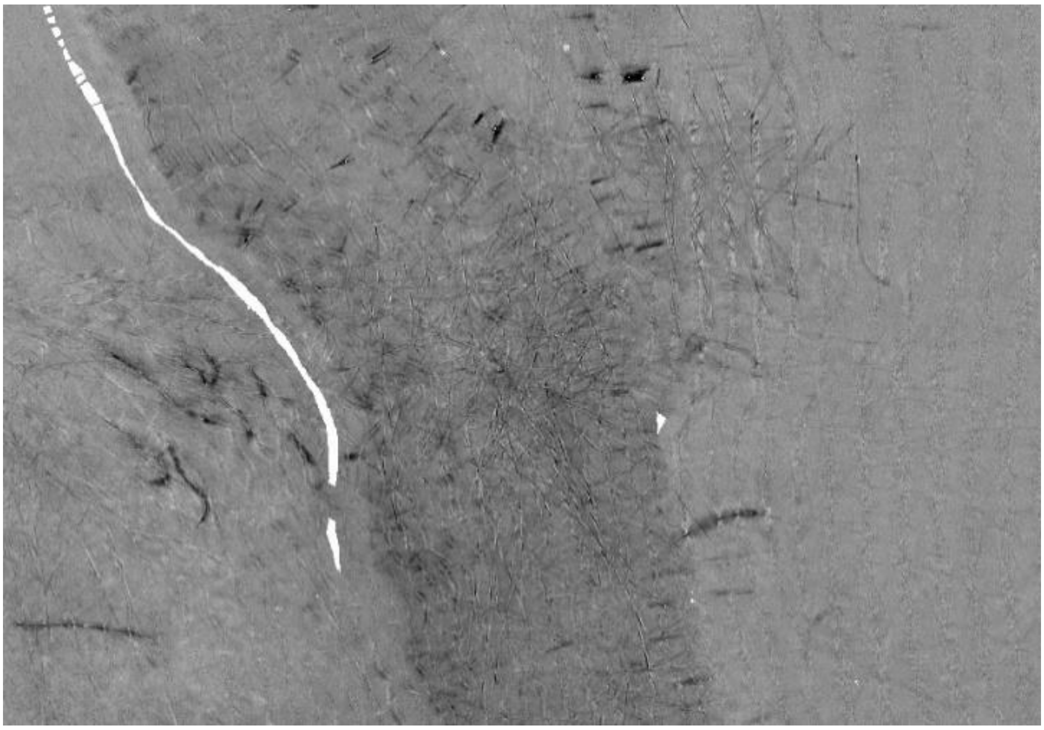


Figure 32. Multibeam acoustic image of the seafloor in an area of the north Irish sea where fishing for razor clams occurs. Individual dredge tracks can be seen representing furrows on the seafloor associated with sediment disturbance caused by the hydraulic dredge (source: Infomar).

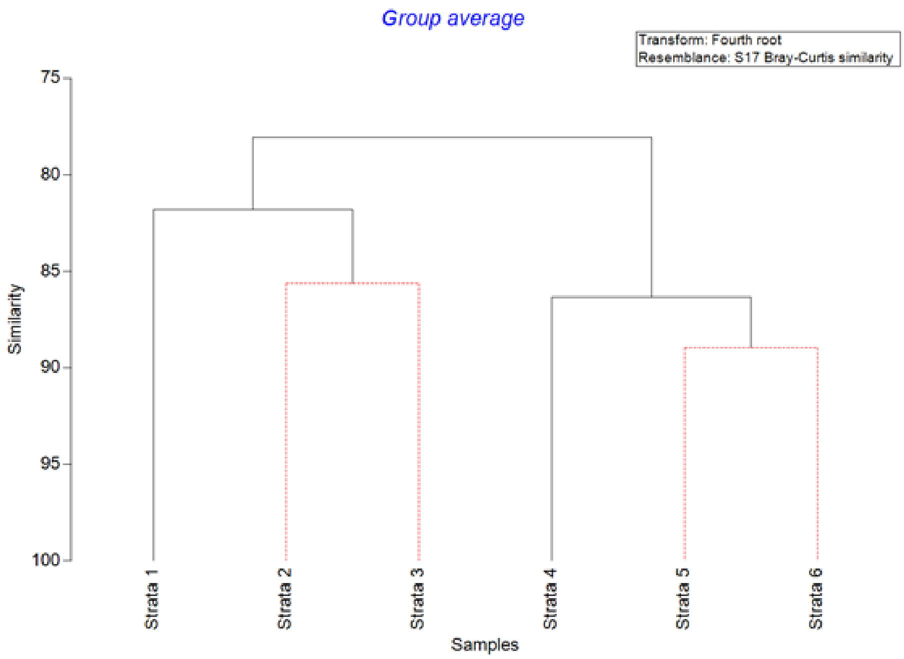


Figure 33. Dendrogram of hierarchical agglomerative clustering output to classify benthic grab sample data from the North Irish Sea, collected from six different fishing intensity strata (defined by iVMS hours). Strata joined by black lines are significantly different, while those joined by red lines are not.

Cluster analysis of faunal data showed that Strata 1-3 (lower effort) were significantly different to Strata 4-6 (higher effort). Within these groups Strata 1 was different to Strata 2 and 3 and Strata 4 was different to Strata 5 and 6 (Figure 33).

These results, showing differences in abundances within faunal communities in areas of high and low fishing effort, were similar when considering bivalve fauna only. Table 6-4 also shows an initial decline in number of taxa (S) and mean number of individuals (N) from the lowest effort strata (1) compared to Strata 2, however these indices show an overall increase from Strata 2 to higher effort strata. The mean abundances of some bivalve species were found to be higher in areas which had received higher levels of fishing effort (Table 6-4).

Table 6-4. Mean values of the bivalve diversity indices calculated across each of the six fishing intensity strata, including the range for the number of taxa per strata.

Strata	Number of taxa (S)		Mean Number of individuals (N)	Mean Margalef's species richness index (d)	Mean Pielou's evenness index (J')
	Mean	Range			
1	9.82	3-18	142.62	1.87	0.66
2	8.70	3-16	131.83	1.66	0.65
3	9.10	3-15	140.45	1.69	0.67
4	11.12	5-18	185.29	2.01	0.68
5	12.64	6-17	226.94	2.19	0.65
6	12.25	5-18	235.53	2.09	0.60

6.5.7.2 Long term effects on deep burrowing bivalve fauna

Monitoring of bivalve fauna by-catch from the north Irish Sea razor fishery was undertaken from 2001 to 2008 and in 2018 additional samples were collected during the survey to investigate whether there have been any changes to the infaunal bivalve benthic community over time. These samples were collected to monitor changes in deep burrowing bivalve infauna which are caught as by-catch.

Table 6-5. Mean values of the diversity indices calculated from the Bivalve data across each of the four dredge sampling events, including the range for the Number of taxa per strata

Dredge Sample	Number of taxa (S)		Mean Number of individuals (N)	Mean Margalef's species richness index (d)	Mean Pielou's evenness index (J')
	Mean	Range			
Gormanstown Pre 2009	4.9	2-7	173.5	0.87	0.64
Gormanstown 2018	3.5	1-6	89.2	0.69	0.40
Skerries Pre 2009	5.8	5-7	350.3	0.84	0.58
Skerries 2018	2.4	1-7	18.6	0.46	0.63

The mean number of bivalve taxa decreased in Gormanstown and Skerries from pre 2009 to 2018. The mean number of individuals also declined in both areas from pre 2009 to 2018 (Table 6-5).

Recent monitoring of by-catch in the 2017-2019 razor clam surveys also indicate both spatial and temporal differences of bivalves. Area 1 (Dundalk) had the lowest number of taxa and individuals compared to other areas. The bivalve fauna in Dundalk Bay is less diverse and less abundant than in other areas in the fishery and is declining (Figure 34).

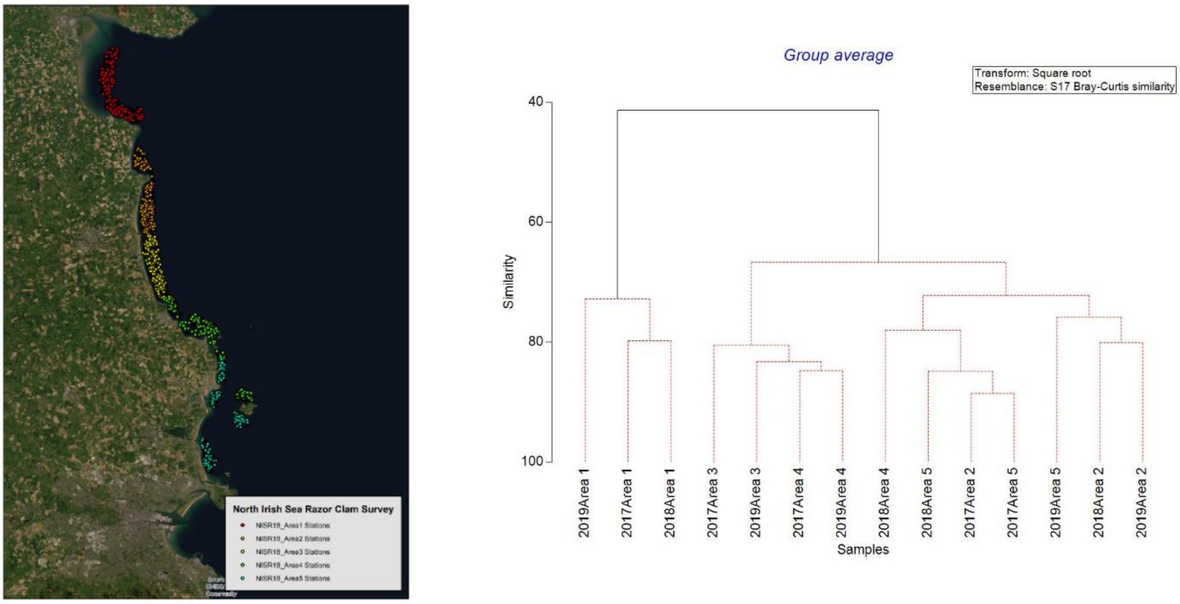


Figure 34. Areas of the North Irish Sea surveyed in 2017-2019 (left) and cluster analysis of bivalve fauna by year and area. The black line between Area 1 (Dundalk Bay) and the other areas indicates its significantly different to other areas.

6.5.7.3 Effects on seabirds which feed on bivalves

Common scoter, a diving seaduck which feeds on bivalves, is protected in European waters under the Birds Directive (79/409/EEC) and the Habitats Directive (92/43/EEC). In Ireland, Dundalk Bay SPA and SAC is designated for the protection of Common Scoter. Within Dundalk Bay SPA/SAC conservation targets are 'to maintain the favourable conservation condition of common scoter' so that long term population trends are stable or increasing and there is no significant decrease in the numbers or range of areas used by the species other than that occurring from natural patterns of variation.

Digital aerial surveys were completed in the winter of 2018-2019 to estimate the population size and distribution of Common Scoter in coastal waters of the North Irish Sea. Estimated abundances of Common Scoter from these surveys were: December survey 1: 10,580 (95% CI 1,285-26,823); December survey 2: 14,612 (95% CI 1,038-39,694); January: 7788 (95% CI 2,786 – 14,282); February: 7,246 (95% CI 2,514 – 13,753); March: 7,064 (95% CI 2,544-12,535).

Modelled distribution shows concentrations of Common Scoter in Dundalk Bay SPA and south to Gormanstown (Figure 35). Abundance is higher in shallow waters in areas of fine sediments with higher abundance of surficial bivalves which Common Scoter feed on.

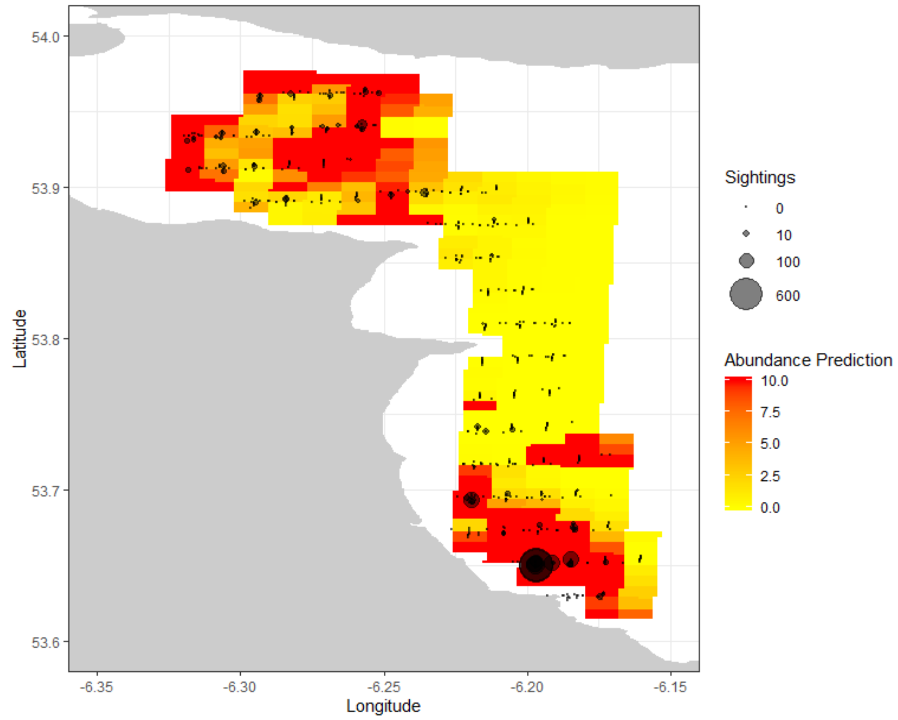


Figure 35. Distribution of Common Scoter from a general additive model using predictors water depth, proportion of fine sand in sediments and abundance of surficial bivalves.

6.5.7.4 Disturbance potential

Common Scoter is known to be particularly sensitive to disturbance due to the presence of vessels which can cause displacement out of an area. A disturbance indicator was calculated to assess the potential spatial distribution of disturbance on common scoter along the Gormanstown coastline based on inshore VMS data from the razor clam fishery in the area.

The disturbance indicator ($DI_{i,j}$) is defined as the portion of available foraging time lost to fishing per grid cell (800 m * 800 m) per month. It is calculated as:

$$DI_{i,j} = \frac{foraging\ hours\ lost}{foraging\ hours\ available}$$

where foraging hours lost is calculated as the number of days per cell per month where there was at least one VMS vessel ping, times the average daylight hours for that month. The foraging hours available is calculated as the total number of days per month times the average daylight hours for that month giving a total available foraging time for Common Scoter.

The calculated disturbance indicator shows high potential disturbance of Common Scoter particularly off the coast of Gormanstown and further north between Clogherhead and Dunany Point. Disturbance was as high as 0.9 in January (0.75 December, 0.9 January, 0.6 February, 0.7 March) in some areas indicating that there is vessel presence 90 % of daylight hours in those areas (Figure 36).

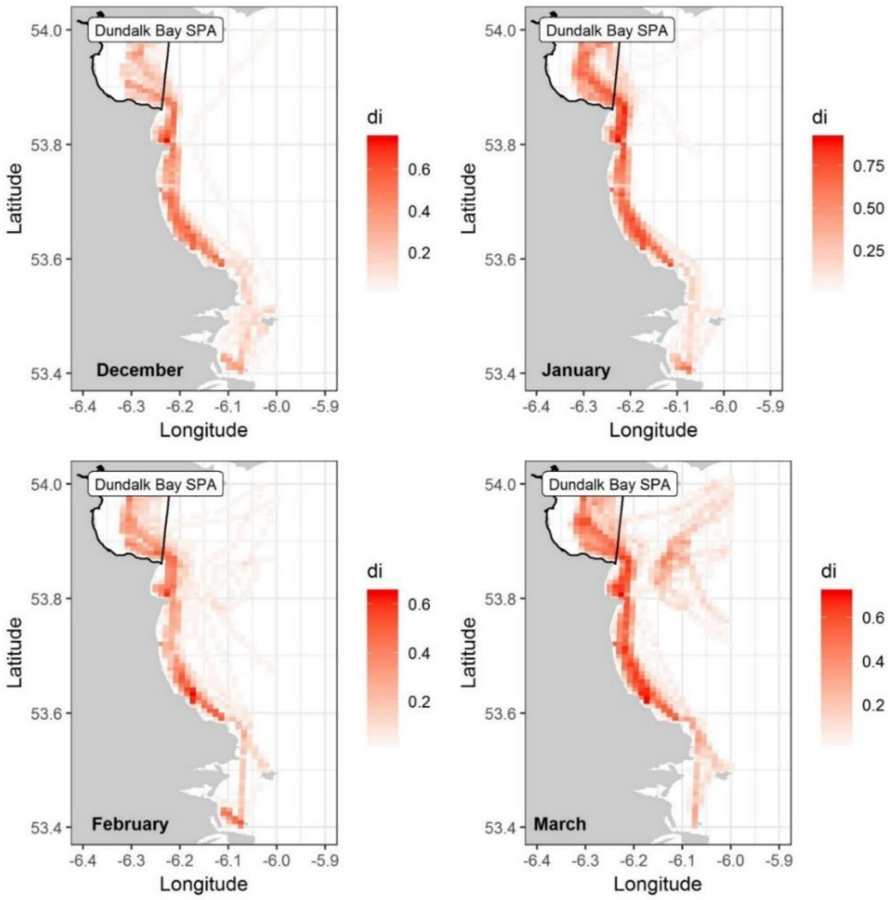


Figure 36. Disturbance Indicator per month calculated as the portion of foraging time lost due to vessel presence. Value of 1 indicates total displacement.

6.5.7.5 Summary of effects of razor clam fishing on common scoter and seafloor

- Estimated disturbance indicators show the potential for high disturbance and displacement of Common Scoter from their feeding grounds in shallow coastal waters of the north Irish sea due to the presence of fishing vessels. Data from aerial surveys is insufficient to show the actual presence or absence of the disturbance effect.
- There is clear evidence that Common Scoter forage on surficial bivalves as opposed to deep burrowing bivalves in the area. Therefore, any changes in structure and function of the habitat resulting from the razor clam fishery will impact on the foraging of Common Scoter. The main impact of the fishery seems to be on deep burrowing large bodied bivalves rather than surficial bivalves. However, change in deep burrowing bivalves represents a significant change in community structure and function in these habitats. In particular, there may be reduced bioturbation. Given the level of sediment mobilisation and abrasion pressure on these communities from fishing, changes in seafloor communities are expected especially where such communities occur in sheltered less exposed coastal areas.

6.6 South Irish Sea

6.6.1 Landings

The fishery opened in quarter 4 of 2010 and landings increased annually up to 2013 to over 350 tonnes (Figure 37). Landings declined annually from 2013 to 95 tonnes in 2018 and approximately 50 tonnes in 2019. 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.

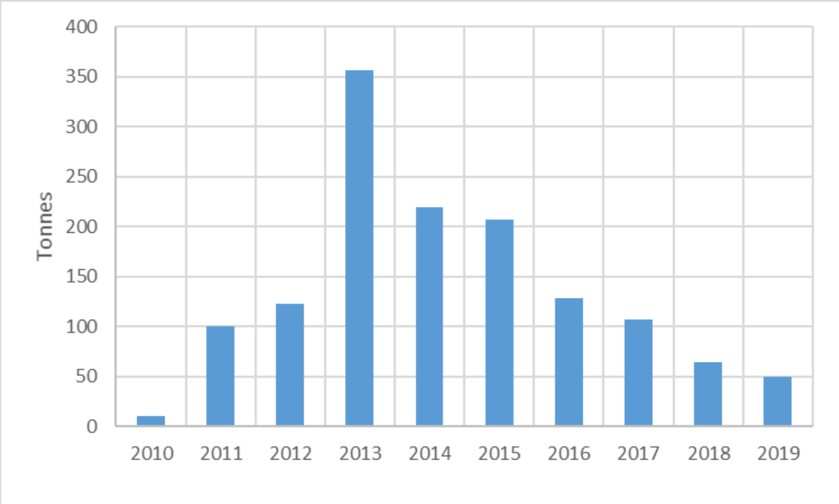


Figure 37. Annual landings estimated from a combination of logbook and gatherers data of razor clams in the south Irish Sea 2010-2019. The fishery opened in Quarter 4 of 2010.

6.6.2 Rosslare Bay

6.6.2.1 Survey 2019

A survey was completed on the MFV Leah Marie during August 1st and 2nd 2019 using a hydraulic (water jet) dredge of 1.06 m width. A total of 50 stations were sampled during the survey in an area of 11.2 km^2. The eastern boundary of the survey extended beyond the eastern boundary of the classified production area (CPA) (Figure 38).

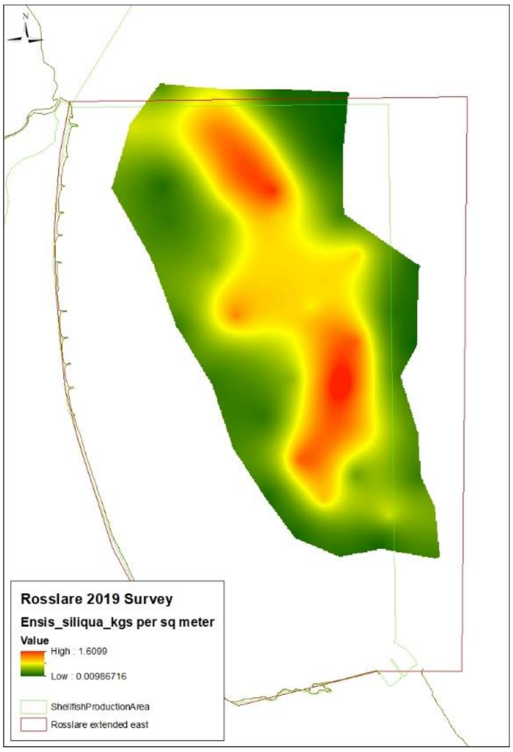
The biomass of razor clams in the survey area was 6,359 tonnes compared to 4,174 tonnes in 2018 and 2,901 tonnes in 2017 (Table 6-6). Biomass of commercial size classes over 130 mm increased from 2,000 tonnes in 2018 to 5,348 tonnes in 2019 and clams over 150 mm increased from 443 tonnes to 1,350 tonnes. Biomass differences between years are mainly due to growth; there is no evidence of recruitment into the stock in the past three years. In addition, a patch of large clams was found at and beyond the northern edge of the classified production areas in 2019 that was not surveyed in 2018. The total survey area in 2019 was 0.7 km^2 higher than in 2018.

Table 6-6. Summary of biomass (tonnes) estimates for razor clams in Rosslare in 2017-2019.

Size category	2017	2018	2019
All	2,901	4,174	6,359
Over 130	784	2,000	5,348
Over 150	0	443	1,350

The highest density of clams ($kgs.m^{-2}$) occurred in a south east to north west axis in the centre of the survey area (Figure 38). The survey bounded the distribution of the stock and densities were low on all edges of the survey area. Biomass (kgs per square meter of seabed) of clams over 150 mm was, however, higher in the north of the survey area and highest densities continued beyond the northern boundary of the classified production area (Figure 38).

Shell material and by-catch of gaper (*Lutraria lutraria*) occurred in high volume in the centre of the survey area.



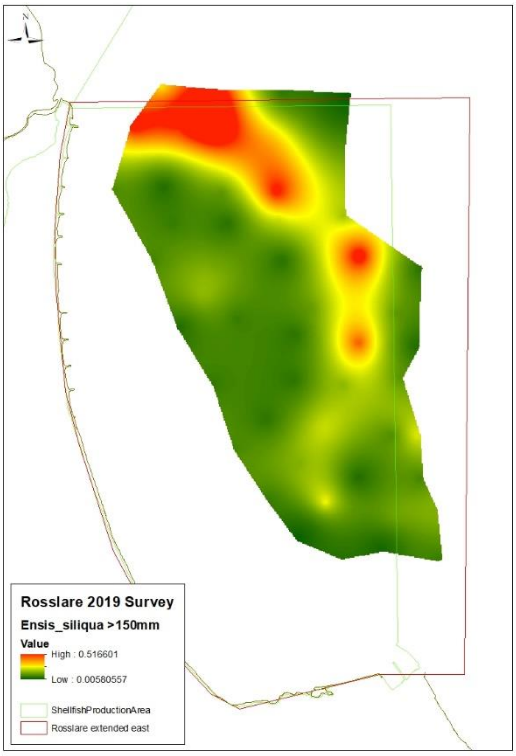


Figure 38. Distribution of biomass and density of razor clams in Rosslare Bay in August 2018. Total on left, clams over 150 mm on right. The production area boundary is shown. The production area extension is proposed but not established.

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 39). 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 and 137 mm in 2019 for a growth of 9 mm between age 5 and 6. Although there are uncertainties in the growth rate estimates the modal size in 2020 could be 145-150 mm and in the absence of recruitment almost all the stock would be over 130 mm.

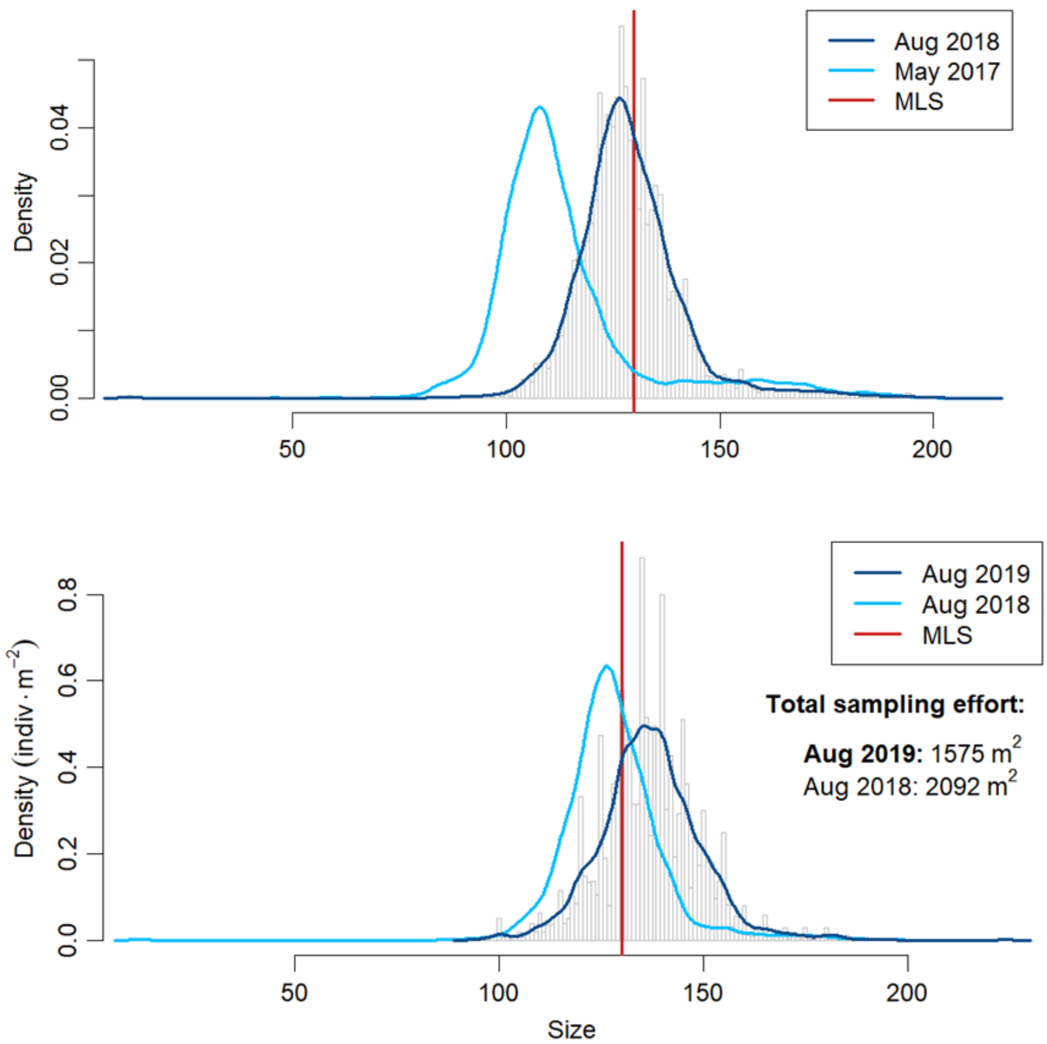


Figure 39. Size distribution of razor clams (*Ensis siliqua*) in Rosslare Bay in May 2017 and August 2018 (top graph) and August 2018 and August 2019 (lower graph). The minimum landings size (130 mm) is shown in red.

6.6.2.2 Catch advice

Survey estimates of razor clam biomass between 2017 to 2019 continue to show significant increase in biomass mainly due to growth of a year class that recruited to Rosslare Bay probably in 2013.

In the absence of reference points advice on catch options for razor clams nationally has been based on 10-15 % of biomass. This would enable a total allowable catch (TAC) of 600-900 tonnes from Autumn of 2019 to Autumn 2020 for Rosslare Bay. This is significantly higher than previous annual landings from Rosslare and Curracloe beds combined, which peaked in 2014 at approximately 400 tonnes. On that basis a TAC of 600 tonnes for August 2019 to August 2020 is advised. In continued absence of recruitment any TAC in further years should be adjusted to the annual survey estimates and as more information on growth and mortality rates in the stock become available from the surveys.

Increases in biomass in the absence of recruitment is a balance between growth and mortality (natural mortality and fishing mortality). Biomass is likely to continue to increase into 2020 as growth outweighs the effect of natural mortality and the proportion of clams in higher grades and the biomass of higher grades will increase.

The commercial value of the proposed TAC of 600 tonnes at €3.50 per kg is €2.1 million given that almost all the clams, especially in the production area, would still be less than 160 mm in 2019. The actual value and the merits of delaying fishing until 2020 depends largely on how value increases with size (grade).

6.6.3 Curracloe

6.6.3.1 Survey 2019

A survey was completed on the MFV Paddy Rose on June 20th and 21st 2019. This was the first survey of this razor clam stock. The hydraulic dredge width was 1.2 m. A total of 70 stations were sampled during the survey in an area of 19.36 km^2. The southern boundary of the survey extended beyond the southern boundary of the classified production area.

The biomass of razor clams in the survey area was 1,024 tonnes (Figure 40). Biomass of commercial size classes over 130 mm and over 150 mm was 881 tonnes and 616 tonnes, respectively.

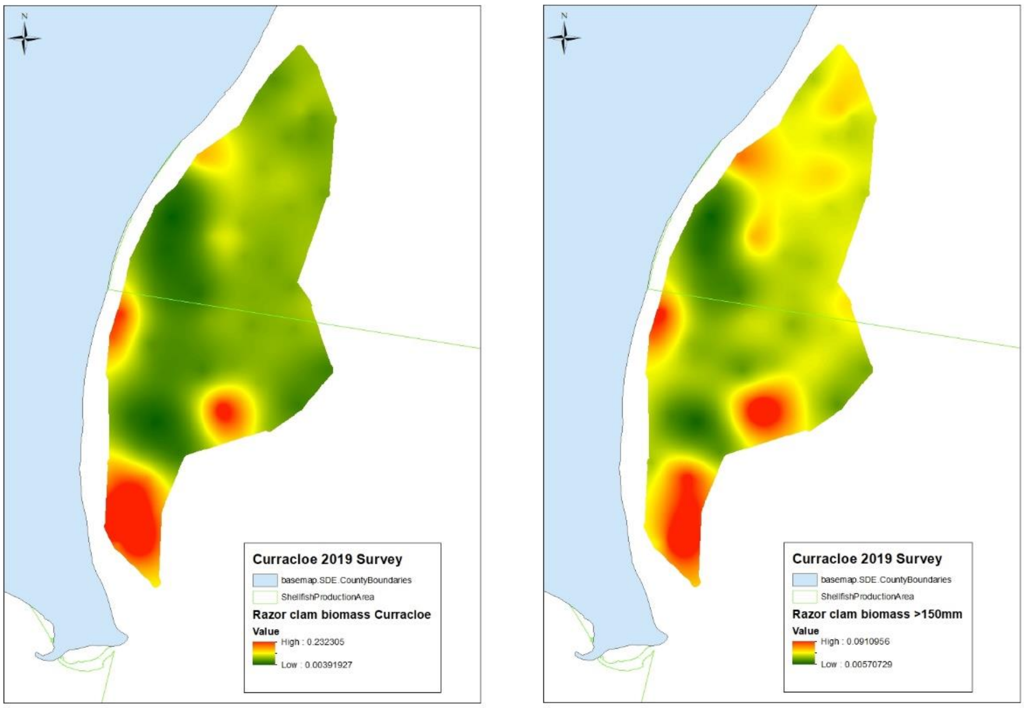


Figure 40. Total biomass (left) and biomass of razor clams over 150 mm off Curracloe, June 2019. The Classified production area is shown.

The modal size distribution of clams was approximately 140 mm. There was no evidence of recent recruitment and few clams below 100 mm were observed (Figure 41).

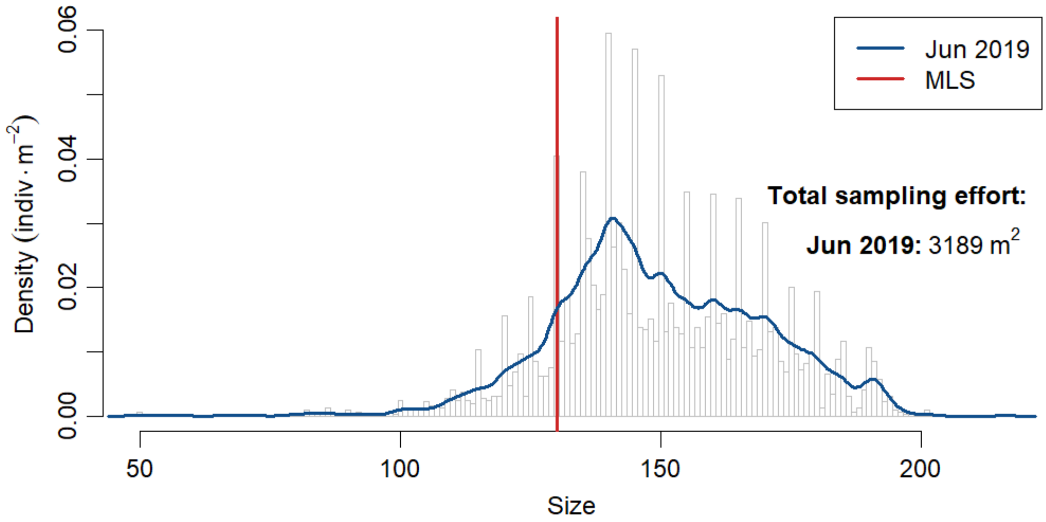


Figure 41. The size distribution of razor clams off Curracloe in June 2019.

6.6.3.2 Catch advice

In the absence of reference points advice on catch options for razor clams nationally has been based on annual exploitation of 10-15 % of biomass. This would enable a total allowable catch (TAC) of 100-150 tonnes from Autumn of 2019 to Autumn 2020 for Curracloe. However, this would have to be taken from the existing production area unless the southern boundary of this area can be reviewed. Taking 100-150 tonnes in the production area may deplete the biomass below commercially viable catch rates.

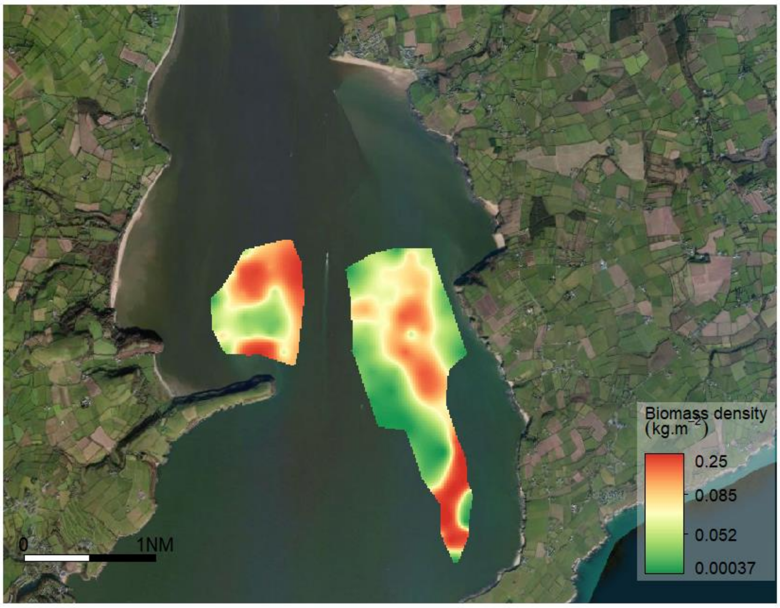
In continued absence of recruitment any TAC in future years should be adjusted to the annual survey estimates and as more information on growth and mortality rates in the stock become available from the surveys.

6.7 Waterford Estuary

6.7.1 Survey

The razor clam stock is distributed in two areas in Harrylock Bay and on the west side of the estuary at Creadon Head. A survey was completed on March 26th, 27th and May 3rd 2019 on the MFV Branwen using a 1.20 m wide hydraulic dredge. The clam bed is distributed over an area of at least 4.2 km^2. A previous less extensive survey was completed in November 2017.

The total biomass of razor clams in the estuary was 439 tonnes compared to 269 tonnes estimated in 2017. High densities occurred on the seaward edge of Harrylock Bay on the east of the Estuary and to the north east of Creadon Head (Figure 42). Approximately 386 tonnes was over 130 mm compared to 216 tonnes in 2017. The size distribution was skewed towards larger size classes (Figure 43) typical of unexploited razor stocks.



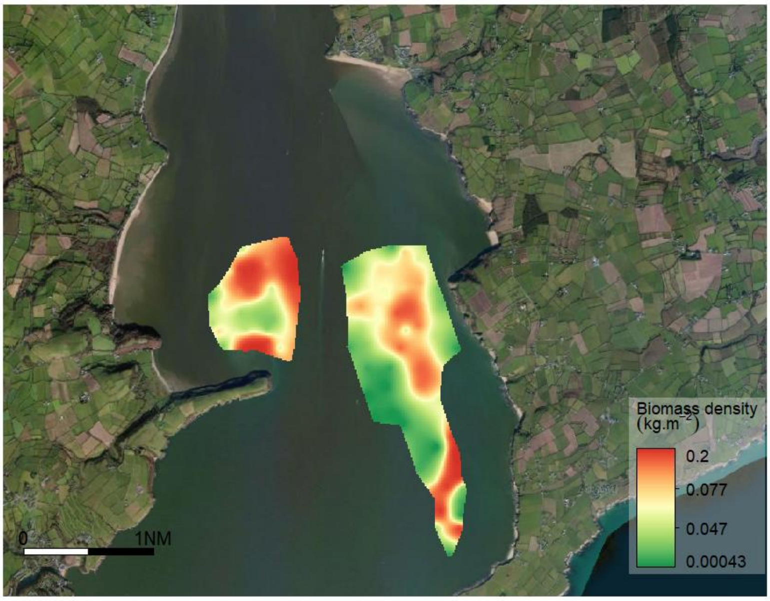


Figure 42. Total biomass (top image) and biomass of razor clams over 150 mm (lower image) in Waterford Estuary, March-May 2019.

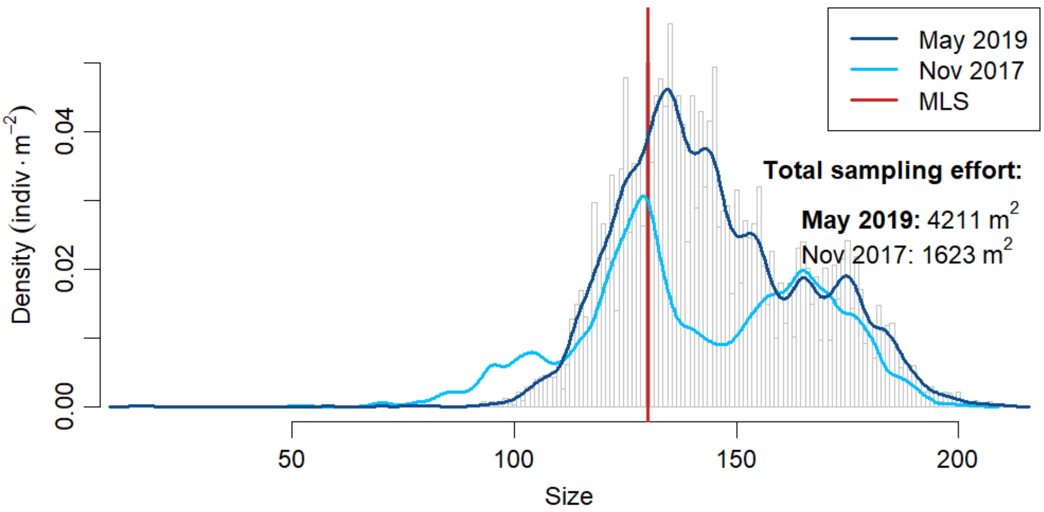


Figure 43. Size distribution of razor clams (*Ensis siliqua*) in Waterford estuary in November 2017 and May 2019.

6.7.2 Catch advice

Biomass estimated from the 2019 survey was 439 tonnes. Catch advice for 2019 and as agreed by the protocols for management of new bivalve fisheries was 44 tonnes based on a 10 % annual rate of exploitation.

6.8 Dungarvan Bay

Dungarvan Bay has not supported a fishery for Razor clams in the past. Based on information from previous exploratory sampling the industry provided approximate location information for the stock in 2019. This was the basis for the 2019 survey.

6.8.1 Survey

A survey was completed in Dungarvan Bay on May 22nd 2019 on the MFV Paddy Rose using a hydraulic dredge of 1.2 m wide. A total of 29 stations were sampled. This was the first survey of the area. Sediments in the area are mixed with high mud and shell content making fishing and survey conditions difficult. The area has not been fished commercially.

Total biomass was estimated to be 91 tonnes. The distribution is patchy with higher densities at the seaward edge of the survey area (Figure 44). Typical of unfished populations of razor clams the size distribution is skewed towards larger size classes in this case with a modal size of 170 mm (Figure 45).

6.8.2 Catch advice

No catch advice has been developed for this stock as no management plan was agreed under the protocols for opening new bivalve fisheries. The survey reported difficult fishing conditions and patchy distribution of clams.

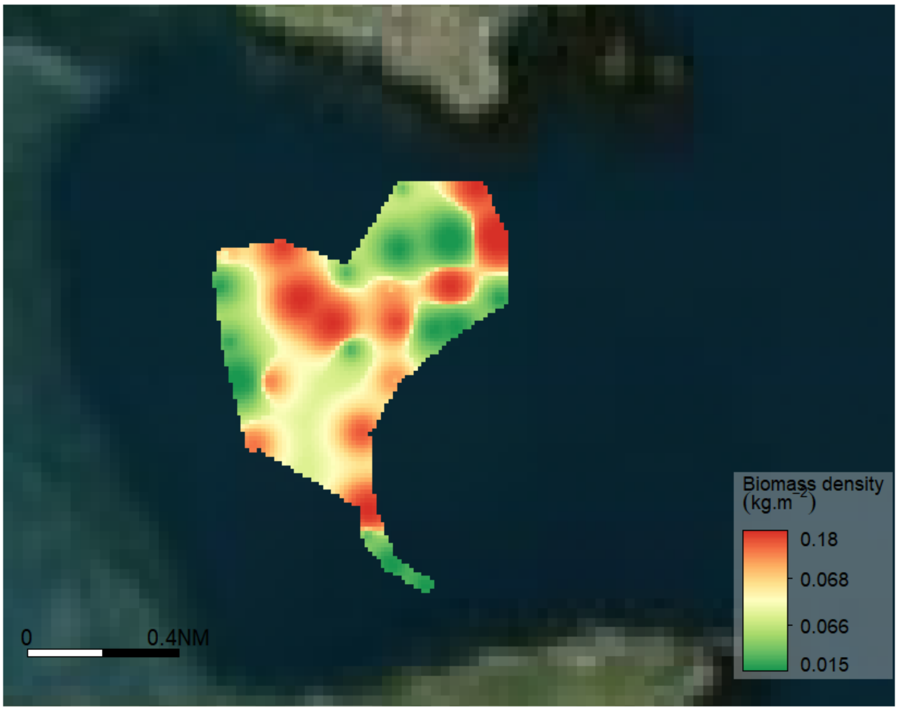


Figure 44. Distribution of razor clams (*Ensis siliqua*) in Dungarvan Bay in May 2019.

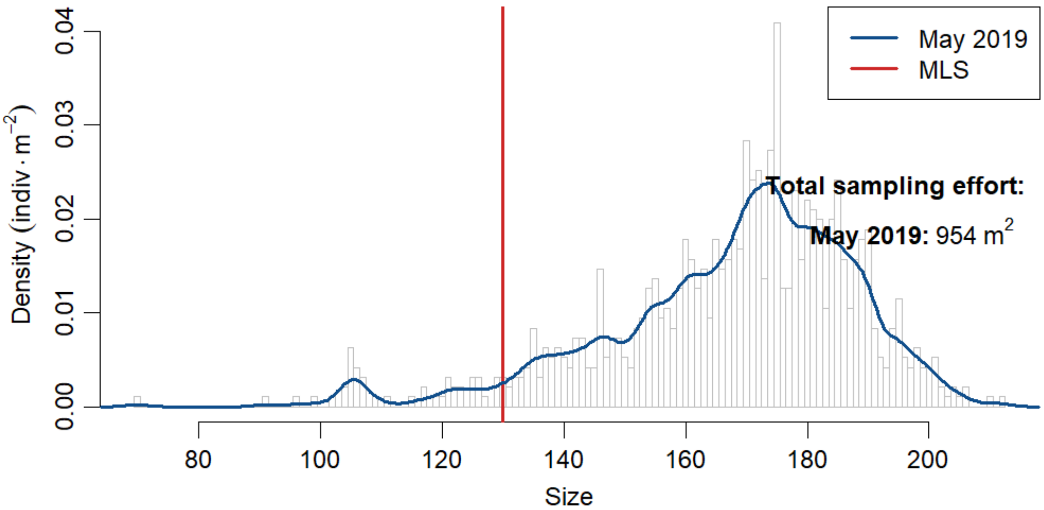


Figure 45. Size distribution of razor clams (*Ensis siliqua*) in Dungarvan Bay in May 2019.

6.9 Ballinakill Bay

6.9.1 Survey

Ballinakill Bay was surveyed for razor clams in February 2019. A previous survey was completed in March 2018. The most abundant species present was *Ensis magnus* with lower densities of *E. siliqua*. The area surveyed was 0.38 km^2 (Figure 46, Figure 47). The area was fished in 2018 and 2019.

Biomass of both species was approximately 50 % of the biomass in 2018. Biomass of *E. magnus* in 2019 was 37 tonnes compared to 85 tonnes in 2018. Biomass of *E. siliqua* was 3 tonnes in 2019 compared to 5 tonnes in 2018. The total landings in 2018 was limited by TAC at 13 tonnes. The survey area was similar in both years. In 2019 some tows were also taken on the south shore west of the area fished in 2018. Densities of clams were low and this area has not been included in the 2019 assessment.

The size distribution was similar in 2018 and 2019 with a modal size of approximately 135 mm and little evidence of recruitment (Figure 48, Figure 49).

6.9.2 Catch advice

Catch advice for 2019 was 6 tonnes for *E. magnus* and 0.5 tonnes for *E. siliqua* based on a harvest rate of 15 % of biomass. The fishery in 2018 and 2019 operated under a management plan for new bivalve fisheries.

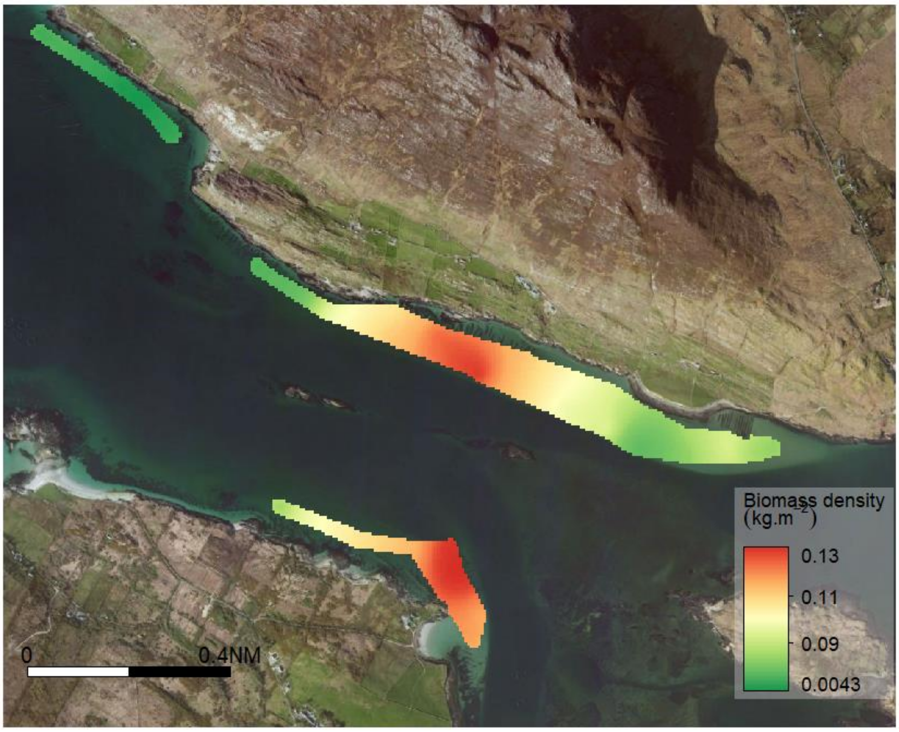


Figure 46. Distribution of *Ensis magnus* in Ballinakill Bay in February 2019.

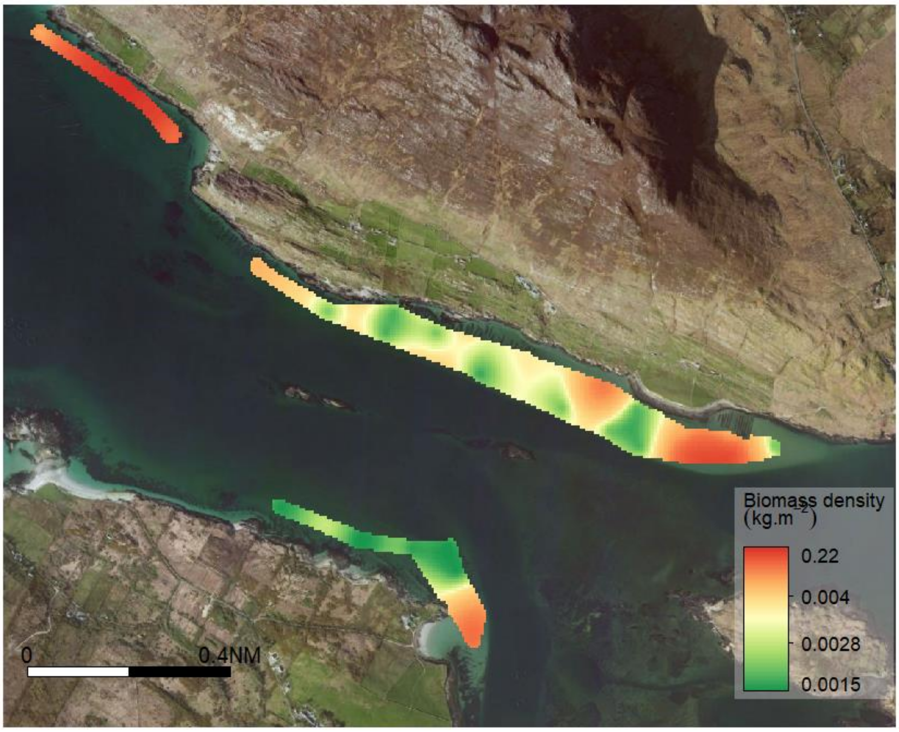


Figure 47. Distribution of *Ensis siliqua* in Ballinakill Bay in February 2019.

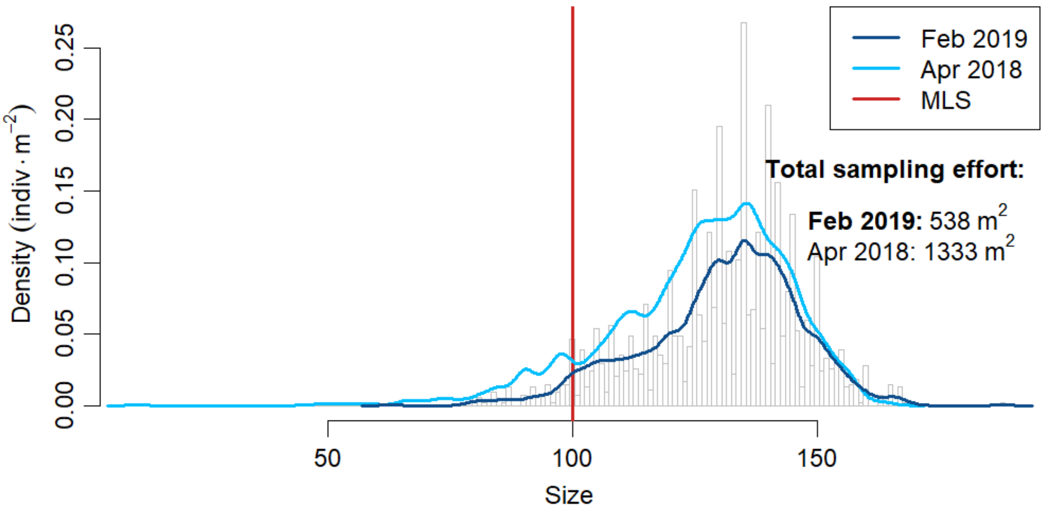


Figure 48. Size distribution of razor clams (*Ensis magnus*) in Ballinakill Bay in April 2018 and February 2019.

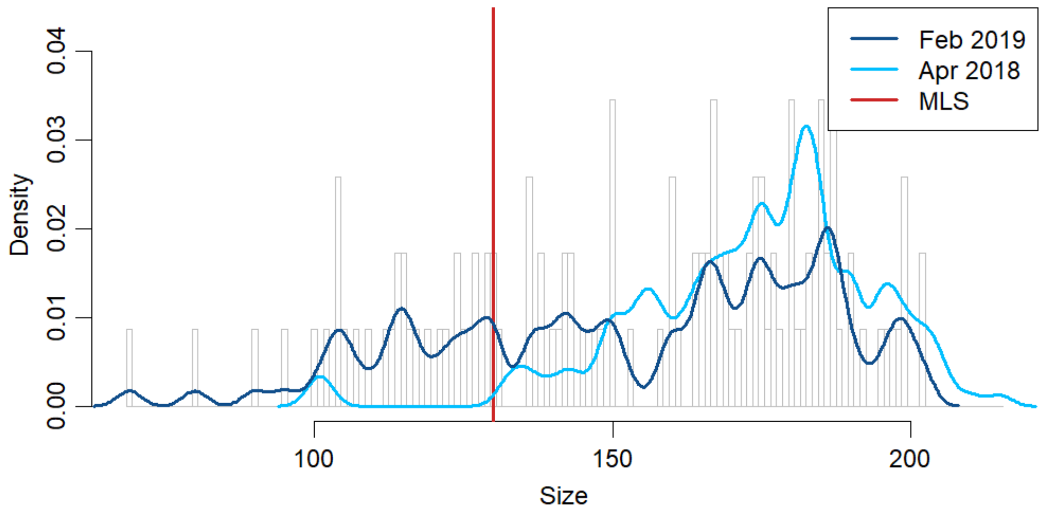


Figure 49. Size distribution of razor clams (*Ensis siliqua*) in Ballinakill Bay in April 2018 and February 2019.

6.10 Clifden Bay

Clifden Bay is classified for the production of razor clams and a fishery has operated in the Bay for over 30 years. The razor clam stock (*Ensis magnus*) occurs in two areas; on the north and south shores of the inner Bay and east of Turbot Island in the outer Bay.

6.10.1 Survey

A survey was completed on 28th and 29th February 2019 sampling 46 stations on the MFV Lantern using a hydraulic dredge. Biomass estimates were lower than in 2016 or 2017 at 70 tonnes in the inner Bay and 22 tonnes in the outer Bay (Figure 50, Figure 51, Table 6-7). Modal size was approximately 125 mm in both areas with evidence of recent recruitment (Figure 52).

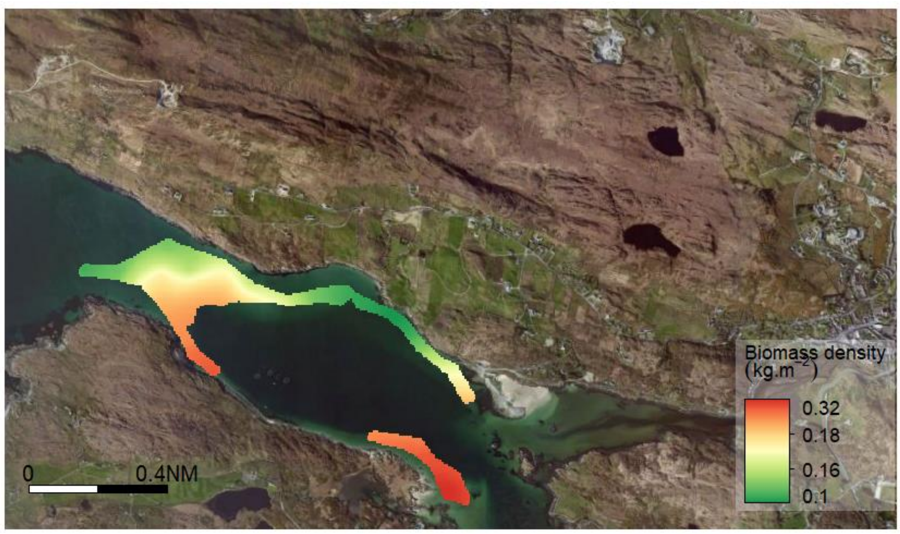
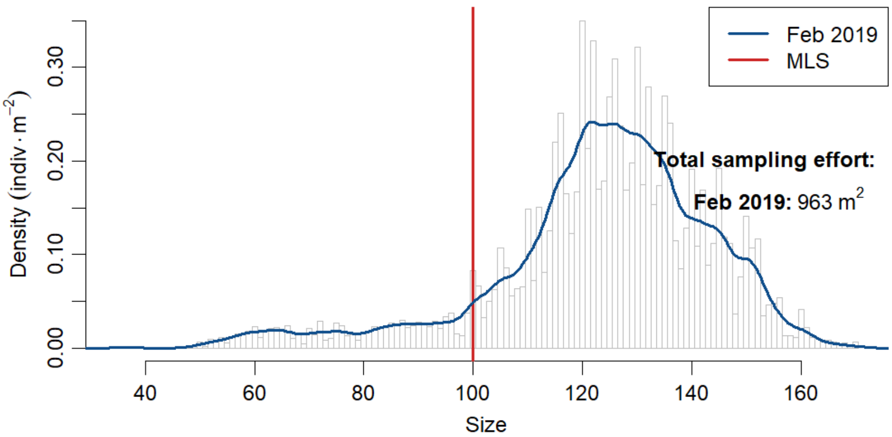


Figure 50. Distribution of *Ensis magnus* in inner Clifden Bay in February 2019.

Figure 51. Distribution of *Ensis magnus* in outer Clifden Bay in February 2019.



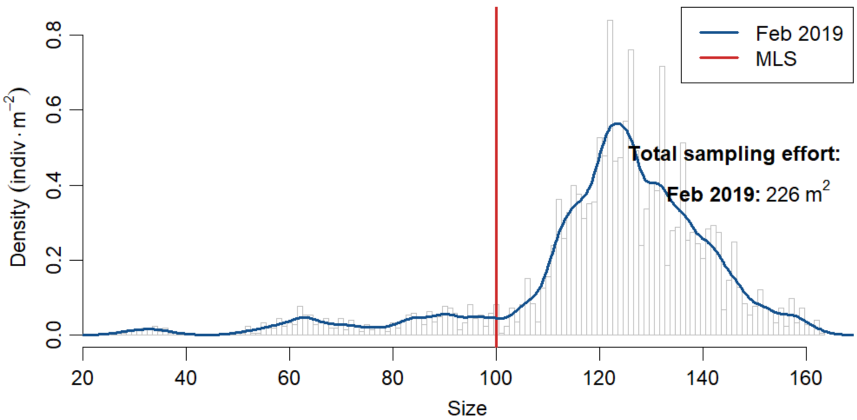


Figure 52. Size distribution of *Ensis magnus* in inner (top graph) and outer (lower graph) Clifden Bay in February 2019.

Table 6-7. Summary of biomass (tonnes) estimates for razor clams in Inner Clifden Bay and Turbot Island 2016-2019.

Year	Survey Month	Stock Unit	Survey Area (km^2)	Biomass		Catch advice (TAC)
				Mean	95% CL	
2016	April-May	Clifden Bay	0.45	230.6	14.5	50
2017	August	Clifden Bay	0.75	114.1	88.4	24
2018						
2019	February	Clifden Bay	0.38	70.0	28.0	11
2016	May	Turbot Island Clifden	0.07	63.9	6.9	
2017	August	Turbot Island Clifden	0.05	32.0		6
2018						
2019	February	Turbot Island Clifden	0.08	22.0		3

6.10.2 Catch advice

Total Allowable Catch for 2019 was 14 tonnes (Table 6-7). Clifden Bay previously supported annual outtakes of 25-30 tonnes per annum for extended periods of time but biomass declined significantly between 2016 and 2017 due to new vessels entering the fishery.

7 Cockle (*Cerastoderma edule*)

7.1 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 survey estimate of biomass in 2019 was 3,790 tonnes. This was the highest since surveys began in 2007. The TAC for 2019 was 600 tonnes. Landings were 594 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 at biomass between 850-1,500 tonnes should be reduced.

7.2 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 habitats 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.

7.3 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.

7.4 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 28 (formerly 32).

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.

7.5 Dundalk Bay

7.5.1 Biomass and landings 2007- 2019

Biomass estimates from annual surveys in 2007-2019 are not strictly comparable because of differences in the time of year in which surveys were undertaken (Table 7-1). 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, June or July.

Biomass has varied from a low of 814 tonnes in 2010 to 3,790 tonnes in 2019. Biomass increased annually between 2014 and 2017 from 972 tonnes to 2,316 tonnes. Biomass declined to 1,785 tonnes in 2018 and increased to the highest recorded biomass of 3,790 tonnes in 2019. 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 % (2017-2019). This depends on distribution of biomass and the commercial viability of fishing and market prices.

Table 7-1. Annual biomass, TAC and landings of cockles in Dundalk Bay 2007-2019.

Year	Survey Month	Biomass (tonnes)		TAC (tonnes)	Landings (tonnes)	
		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
2019	July	3,790	110	600	594	0

7.5.2 Survey in 2019

7.5.2.1 Biomass

A pre-fishery survey was completed in July 2019. The survey area was 31.9 km^2. Total biomass was 3,790 tonnes (Table 7-2) based on a Geostatistical model. Biomass of cockles over 22 mm was 1,162 tonnes (Figure 53).

Based on the management plan which specifies a harvest rate of 0.33 and the biomass estimate a TAC of 600 tonnes was advised.

Table 7-2. Biomass of cockles in Dundalk Bay in July 2019.

	Biomass (tonnes)		95% HDI inf
	Mean	Median	
Biomass All sizes	3,790	4,267	3,900
Biomass (tonnes) > 22mm	1,162	1,424	1,264
Biomass (tonnes) > 18mm	2,367	2,696	2,428
Biomass (tonnes) < 18mm	1,236	1,806	1,239

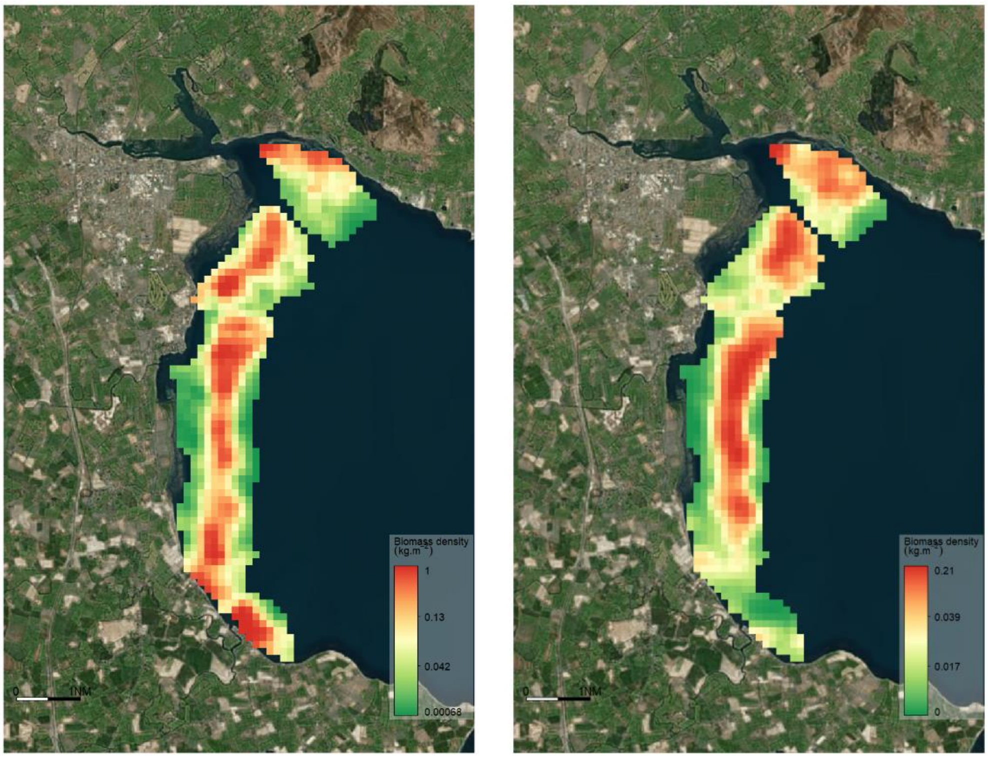


Figure 53. Distribution and density (kgs.m^{-2}) of all cockles (left) and commercial cockles (>22 mm shell width) (right) in Dundalk Bay in July 2019.

7.5.2.2 Size distribution and recruitment

Cockles aged 1+ were strongly represented in July 2019 (Figure 54) following on from the strong 0+ cohort recorded in June 2018. The modal size (measurement across the valves) of cockles in July 2019 was 17.01 mm. From the survey 14 % of the cockles were 0+, over 75 % were 1+ and 7 % were 2+. Weight increases 6 fold between ages 0+ and 2+.

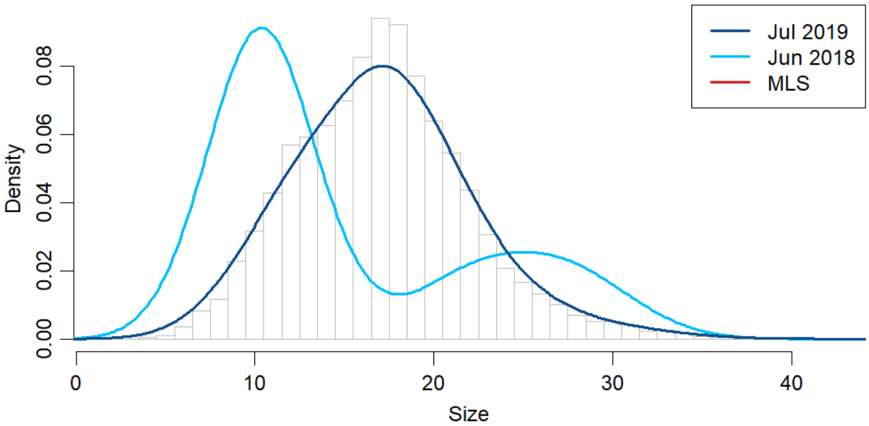


Figure 54. Size distribution of cockles in Dundalk Bay in July 2019 and June 2018.

7.5.3 Fisheries monitoring and exploitation rate

Total landings of cockle from Dundalk Bay in 2019 was 594 tonnes (source: SFPA) from a TAC of 600 tonnes representing 99 % uptake of quota. The fishery opened on August 19th and closed in mid October.

8 Oyster (*Ostrea edulis*)

8.1 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 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. Restoration is consistent with the conservation objectives.

8.2 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 Cill Chiaráin 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 Cill Chiaráin 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.

8.3 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, Cill Chiaráin Bay in Connemara, Clew Bay, Blacksod Bay and Lough Swilly.

8.4 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. Biomass is estimated using a geostatistical model accounting for spatial autocorrelation in the survey data.

8.5 Inner Tralee Bay

8.5.1 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 8-1).

Table 8-1. Stocks biomass trends for native oyster in Inner Tralee Bay 2010-2019.

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
2019	October	3.7	237.57	879

8.5.2 Survey October 2019

8.5.2.1 Biomass and landings in 2019

A pre fishery survey was completed on October 1st and 2nd 2019 on the inner Tralee Bay Oyster Bed. A total of 57 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 3.7 km^2 east of Fenit pier (Figure 55).

Biomass of oysters uncorrected for dredge efficiency varied from 0-0.69 $kgs.m^{-2}$. Biomass of oysters over 76 mm ranged from 0-0.19 $kgs.m^{-2}$.

Total biomass of oysters, assuming a dredge efficiency of 35%, was 879 tonnes (Table 8-2). The equivalent biomass of oysters 76 mm or over was 257 tonnes.

Table 8-2. Distribution of oyster biomass, corrected for a dredge efficiency of 35%, in Inner Tralee Bay in October 2019.

	Biomass (tonnes)		95% confidence intervals	
	Mean	**Median**	**Lower**	**Upper**
Uncorrected for Dredge Efficiency				
Biomass_***Ostrea_edulis***	309	301	182	478
Biomass_>76mm_***Ostrea edulis***	90	88	52	141
Corrected for 35% Dredge Efficiency				
Biomass_***Ostrea_edulis***	879	857	515	1380
Biomass_>76_Inf_***Ostrea edulis***	257	251	146	405

Figure 55. Distribution of biomass of native oyster in Inner Tralee Bay, October 2019.

8.5.2.2 Size distribution 2019

The size distribution of oysters caught during the survey showed a strong cohort with a size mode of 64 mm and a smaller cohort with a size mode at 32 mm (Figure 56). The size distribution of oysters over 76mm was very similar in 2018 and 2019.

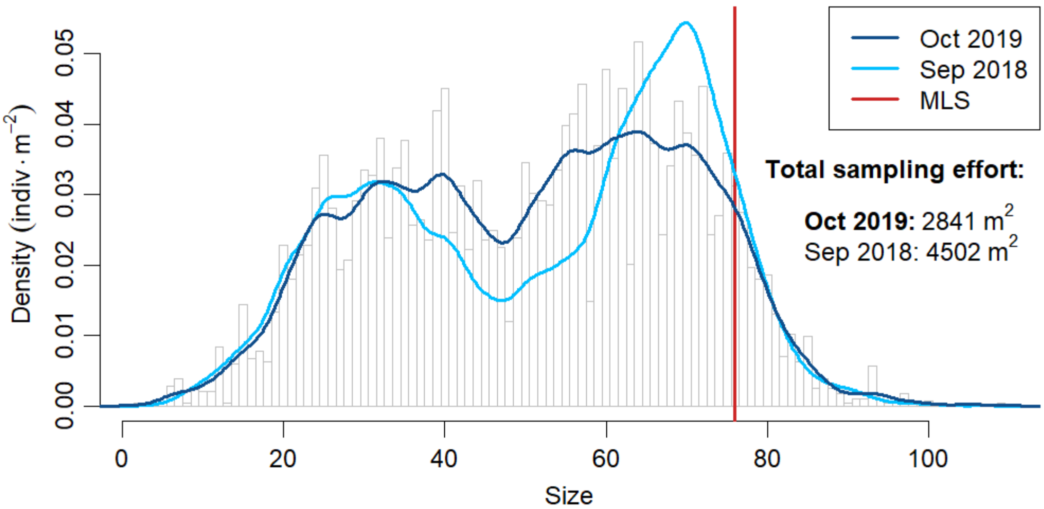


Figure 56. Size distribution of native oysters in the Fenit oyster bed in October 2019. The MLS (76 mm) is also shown.

8.6 *Cill Chiaráin*

8.6.1 Stock trends

Only three surveys had been carried out by the Marine Institute on the Cill Chiaráin beds prior to October 2019 and the surveyed area has varied each time (Table 8-3). Prior to 2010 Taighde Mara Teo and Bord Iascaigh Mhara carried out surveys in 2002, 2003 and 2006. Historically the oyster beds in Cill Chiaráin provided a steady return of 50+ tonnes of native oyster per annum for much of the 1990s and in 1998 120 tonnes were landed. Some habitat management (clutching) occurred at that time but ceased in 1998.

Table 8-3. Stocks biomass trends for native oyster in Cill Chiaráin 2010-2019.

Year	Month	Survey Area (km^2)	Biomass km^{-2}	Biomass
2010-2011	October/January	2.51	30.6	76.81
2012	October	1.06	12.9	13.68
2018	October	2.36	51.3	121.09
2019	October	1.78	38.9	69.2

8.6.2 Survey October 2019

A survey was carried out on October 1st on the oyster beds of Cill Chiaráin Bay. A total of 64 tows were undertaken (63 valid), with a single toothless dredge of width 1.20 m. GPS data for each tow line was recorded on a Trimble GPS survey unit and swept area for each tow estimated. The survey encompassed a combined area of 1.78km^2 within Chill Chiaráin Bay with a total sampling effort of 4,556 m^2.

8.6.2.1 Biomass

Biomass of oysters uncorrected for dredge efficiency varied from 0-0.059 kgs.m^{-2}, with the highest biomasses in seaward parts of the survey area (Figure 57). Biomass of oysters over 76 mm ranged from 0-0.012 kgs.m^{-2} following a similar distribution pattern.

The biomass of oysters, assuming a dredge efficiency of 32.5% provided an estimate of 69 tonnes (Table 8-4). The equivalent biomass of oysters 76 mm (MLS) or over was 14 tonnes indicating that the biomass of commercial size is 20 % of the total stock in the bay. The low number of oysters above 76 mm in the survey, however, affect the reliability of the estimates for larger oysters. Increased sampling effort could improve these estimates. The dredge efficiency co-efficient used was that recorded during the Cill Chiaráin Oyster survey of 2010. Where dredge efficiency was estimated along 17 separate tracks using divers to 32.01±32% resulting in a dredge efficiency raising factor of 3.12.

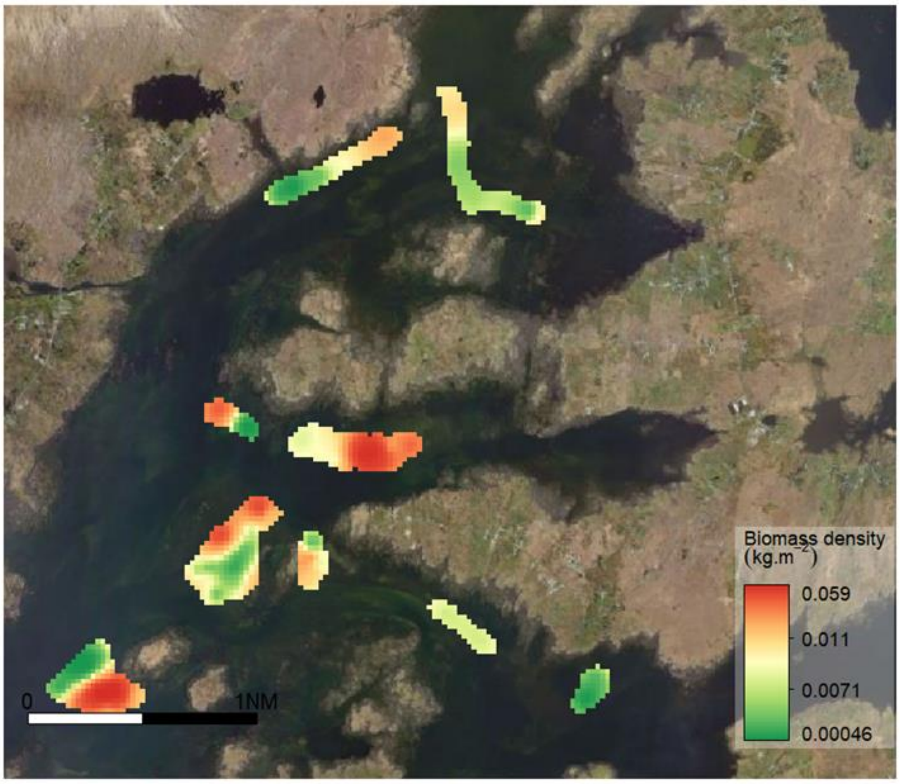


Figure 57. Distribution and biomass of native oyster in Cill Chiaráin in October 2019 (not corrected for dredge efficiency).

Table 8-4. Biomass of native oyster in inner Cill Chiaráin in October 2019 based on a dredge efficiency of 32.5%.

	Biomass (tonnes)		95% confidence intervals	
	Mean	Median	Lower	Upper
Uncorrected for Dredge Efficiency				
Biomass_Ostrea_edulis	22.50	29.80	19.73	41.13
Biomass_>76mm_Ostrea_edulis	4.49	10.76	2.80	1071.95
Corrected for 32.5% Dredge Efficiency				
Biomass_Ostrea_edulis	69.23	93.15	63.84	131.58
Biomass_>76mm_Ostrea_edulis	13.82	33.12	10.10	3019.15

8.6.2.2 Size distribution

The size distribution of oysters caught during the survey shows a reduction in density of individuals, specially under 76 mm compared to 2018 (Figure 58). The strong mode at about 60 mm is still present as previous year. There was no evidence of in year recruitment.

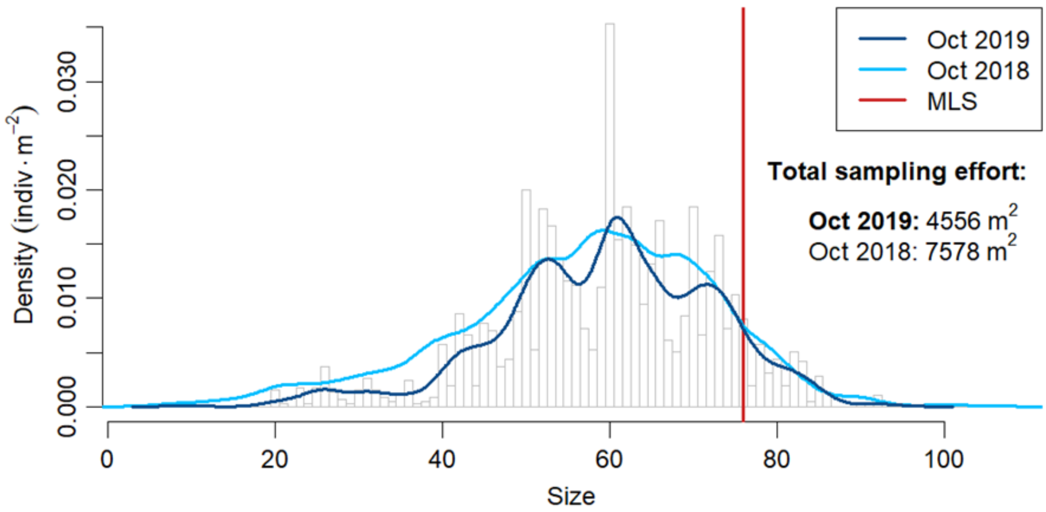


Figure 58. Size distribution of native oysters (*Ostrea edulis*) in Cill Chiaráin in November 2018 and October 2019. The minimum landing size (76 mm) is shown.

8.7 Galway Bay

8.7.1 Stock trends

Oyster biomass has declined in recent years in inner Galway Bay. The area has not supported a commercial fishery since 2016. The main issue seems to be high mortality rates in oysters over 60 mm unrelated to fishing mortality. Survey work both intertidally and sub-tidally was completed in 2018 and 2019 in areas not recently exposed to fishing for comparison with earlier surveys in the commercially fished areas. Work to survey all known areas where beds existed historically is ongoing under an oyster restoration project.

8.7.2 Intertidal surveys in 2018

During autumn and winter of 2018 a broad scale survey of the intertidal zone was completed to describe the distribution of native oysters in the area. Local knowledge of oyster fishermen, oyster farmers and informed local people was used to identify stretches of coastline to include in the survey. The areas to include in the survey were mapped, using GIS in real time, during meetings with local fishermen and oyster farmers.

The survey area was divided into longshore transects and allocated to survey teams. The total transect length was 81 kms (not including any parallel transects at different vertical levels on the same shoreline). The survey design approximated to a concurrent two phase survey with a random stratified approach in the second phase. Surveyors had prior knowledge of areas where oysters were present and were asked to focus on such areas in phase 1 in order to record all known positive occurrences. The surveys then extended from these areas along transects on the shore two hours before and after low water during spring tides. On some shores two parallel transects were covered. The lower shore transect corresponded to the lowest level on the shore accessible around low water on the day of sampling and the transect parallel to it covered an area about 10 m upshore of it. Surveyors sampled a 1 m^2 quadrat at approximately 50 m intervals (Figure 59).

The majority of sampling was completed during spring tides in September and October (74% of samples) which allowed access to the lower shore close to chart datum. All data were submitted by survey teams using a purpose designed mobile phone form using the Fulcrum app (https://www.fulcrumapp.com). This included a photo image of the 1 m^2 quadrat which was used for data validation. Data from over 3,000 quadrats were reported. A full report of the survey is available on www.cuanbeo.com.

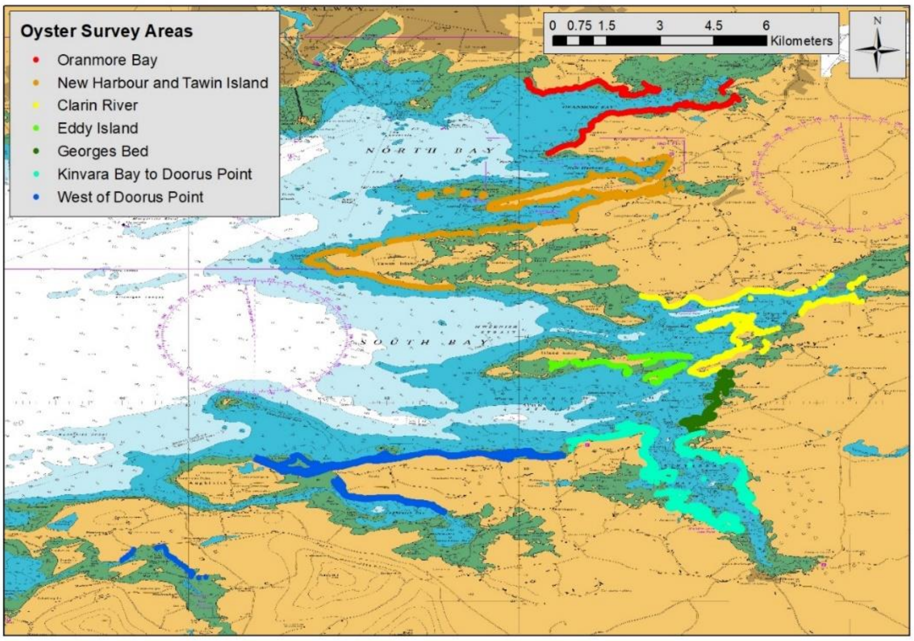


Figure 59. Intertidal survey transects used in a broadscale distribution survey of native oyster in inner Galway Bay in 2018.

The prevalence, or % of quadrats with oysters, varied from 28% in the Clarin River, 14% in Oranmore Bay, 11% at Tawin and less than 10% in other areas (Figure 59, Table 8-4). Densities were generally less than 0.5 oysters.m^{-2} but where oysters were present average density varied from 4.2 oysters.m^{-2} at Tawin, 3.6 oysters.m^{-2} in Oranmore Bay and between 1-2 oysters.m^{-2} in other areas.

Table 8-5. Prevalence (% positive records) of oysters in different areas of the south east Galway Bay during summer-autumn of 2018 (refer to Figure 59 for survey area locations).

Location	N (quadrats)	Absent	Present	Prevalence
Clarin River	660	472	188	28.5%
Eddy Island	157	154	3	1.9%
Kinvara Bay to Doorus	685	632	53	7.7%
New Harbour_Tawin Island	543	484	59	10.9%
Oranmore Bay	264	226	38	14.4%
St. Georges Bed	200	183	17	8.5%
West of Doorus	518	469	49	9.5%

Table 8-6. Density of oysters in different areas of the south east Galway Bay during summer-autumn of 2018 (refer to Figure 59 for survey area locations).

Location	N (oysters)	Density (all quadrats)		Density (>0)	
		Average	St.Dev	Average	St.Dev
Clarin River	442	0.67	1.65	2.35	2.38
Eddy Island	3	0.02	0.14	1.00	0.00
Kinvara Bay to Doorus	90	0.13	0.52	1.70	0.95
New Harbour_Tawin Island	250	0.46	1.83	4.24	3.89
Oranmore Bay	137	0.52	2.11	3.61	4.48
St. Georges Bed	36	0.18	0.66	2.12	1.05
West of Doorus	84	0.16	0.59	1.71	1.00

8.7.3 Subtidal surveys of unexploited oyster beds

A survey was carried out on the 18th and 19th of September 2019 on the oyster beds of Oranmore Bay (Rinville and Mweeloon) onboard the MFV Mirella. A total of 74 tows were undertaken (63 valid; 20 in Rinville and 34 in Mweeloon), with a single toothless dredge of width 1.20 m. A dredge efficiency of 32.5 % was assumed based on trials from similar gears and vessels. The swept area for each tow estimated using GPS survey unit data. The survey encompassed a combined area of 0.97 km^2 within Oranmore Bay , Mweeloon and new Harbour with a total sampling effort of 5,350 m^2 (Figure 60).

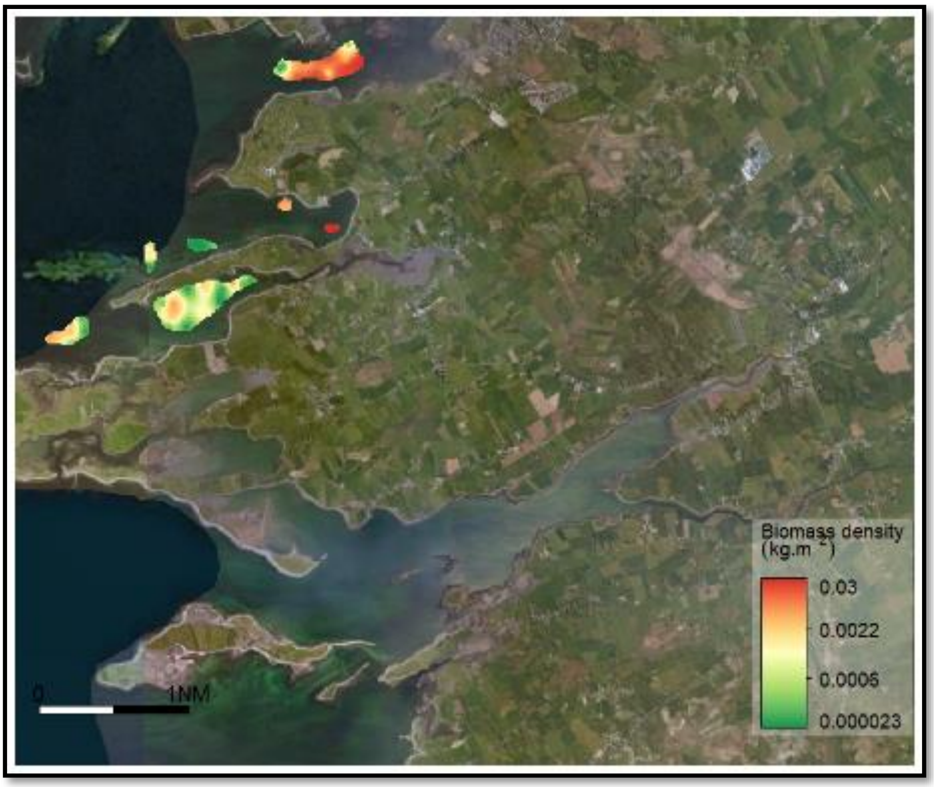


Figure 60. Sub-tidal dredge survey of unfished oysters beds in inner Galway Bay.

The biomass of oysters in the survey area, assuming a dredge efficiency of 32.5 %, was 8.5 tonnes. The equivalent biomass of oysters 76 mm was 0.46 tonnes indicating that the biomass of commercial size was 5.40 % of the total stock in the bay. The size distribution was bi-modal suggesting variable recruitment in the previous 5 years. Numbers of oysters declined significantly above 60 mm indicating high mortality rates between 60-80 mm (Figure 61). Given the absence of fishing mortality this figure suggests high rates of natural mortality in the survey areas.

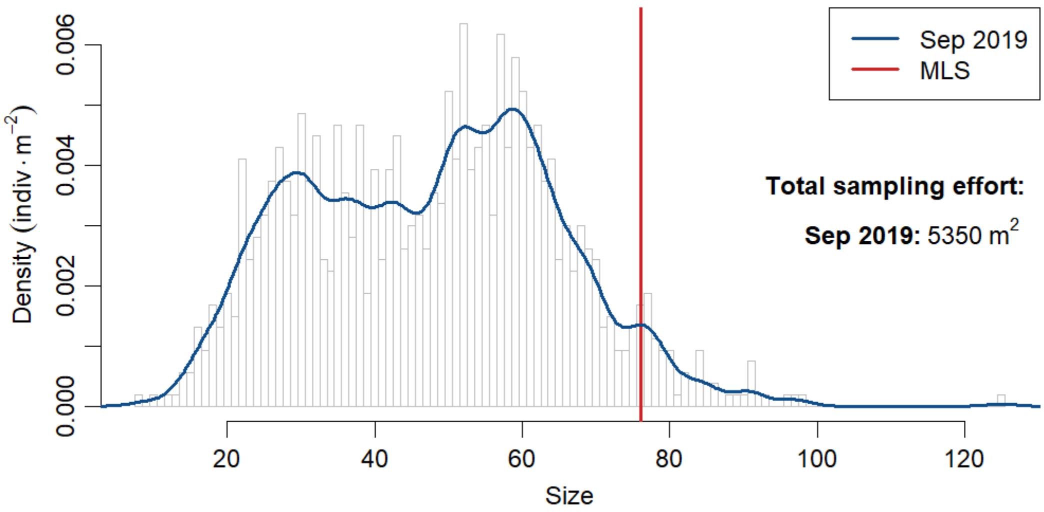


Figure 61. Sub-tidal dredge survey of unfished oysters beds in inner Galway Bay, September 2019.

9 Scallop (*Pecten maximus*)

9.1 Management advice

Offshore scallop stocks are fished by Irish, UK and French fleets. There is currently no international assessment. Spatially referenced catch rate indicators have been developed for the Irish fleet in the Celtic Sea, Irish Sea and English Channel. Some inshore stocks are assessed by survey, and more recently the Celtic Sea and South Irish Sea stocks have been surveyed which provides relative biomass estimates.

Effort distribution across stocks varies annually. The Celtic Sea stock is the most important to the Irish fleet. From 2006–2012, catch rates increased for most stocks but declined in the period 2013–2016 in the Celtic Sea and Irish Sea. An increase in catch rate was seen in some areas in 2017 followed by a subsequent decrease in 2018. Irish fleet effort and landings has increased in the Eastern English Channel in recent years, but this fishery is recruitment driven and future catch rates may, therefore, be more variable than in other stocks.

Fishing effort/landings should be managed at the stock level in proportion to changes in spatially referenced standardised catch rate indicators, using data for all fleets, until more comprehensive assessments are developed.

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.

9.2 Issues relevant to the assessment of scallop

No analytical assessments are currently undertaken. 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 in the Celtic Sea. Recent surveys in the Celtic Sea and the Tuskar/Barrels area of the South Irish Sea have resulted in relative biomass estimates for the areas surveyed (see section 9.6). 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 (e.g. see Figure 75).

The main uncertainty in survey estimates is catchability which varies according to ground type. Surveys carried out in the Celtic Sea have indicated that scallops are present in densities up to five times higher on coarse sediments, comprised mainly of gravel, compared to sand sediments. Geostatistical analysis of survey data can allow these differences across ground types to be taken into account, but only when a complete seabed/substrate map is available for the surveyed area.

A number of other approaches to assessment have been explored including depletion assessment of commercial catch and effort data with variable success. Age-based stock assessment methods commonly applied to exploited aquatic species are used in some countries for the assessment of scallop. However, these methods rely on the collection of accurate age data which is difficult to obtain for some stocks such as the Celtic Sea.

9.3 Management units

Offshore scallop stocks in the Irish Sea, Celtic Sea and Western and Eastern English Channel are spatially discrete following settlement (Figure 62), but some can be variously interconnected during larval dispersal following spawning. Larval dispersal simulations show connectivity between the south Irish Sea and north east Celtic Sea, but limited east-to-west connectivity across the south Irish Sea between stocks in Cardigan Bay and off the Irish coast. There is also a general separation of stocks in the Northern Irish Sea and around the Isle of Man from stocks further south. Genetic studies to identify stock structure are ongoing.

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.

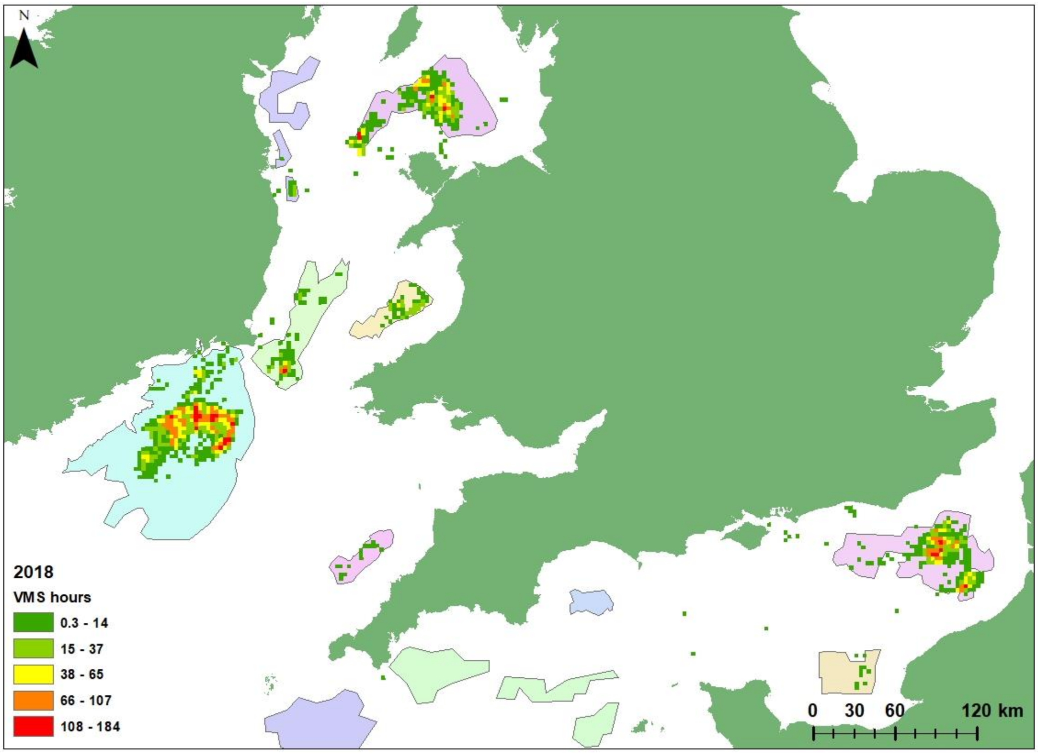


Figure 62. Scallop grounds fished by the Irish fleet in the Irish Sea, Celtic Sea and English Channel. Boundaries are defined from the distribution of fishing activity by the Irish fleet 2000–2015 as shown by VMS data and some UK VMS data. The stock boundary limits are likely to be larger particularly in inshore areas of the Irish Sea and English Channel considering that the UK and French fleets fish mainly in these areas. VMS data from the offshore Irish fleet for 2018 (raster 3 km^2 grid) are shown relative to the spatial extent of the stocks that are fished.

9.4 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 63). In 2019 the number of dredges on vessels over 10 m was estimated to be approximately 208 compared to the estimated 522 dredges prior to the decommissioning of part of the fleet in 2006. Vessels under 10 m in length are unrestricted.

The minimum landing size (MLS) is 100 mm shell width for most of the offshore stocks other than those in the Irish Sea north of 52.5°N where the MLS is 110 mm. For some inshore stocks, MLS 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 e.g. Cill Chiaráin Bay, Co. Galway.

Scallop fishing is excluded from areas supporting sensitive habitats. These include seagrass, maerl and reef communities in Roaringwater Bay, Co. Cork and Blacksod Bay, Co. Mayo, as well as the SACs established south of the Saltee Islands and Hook Head, Co. Wexford.

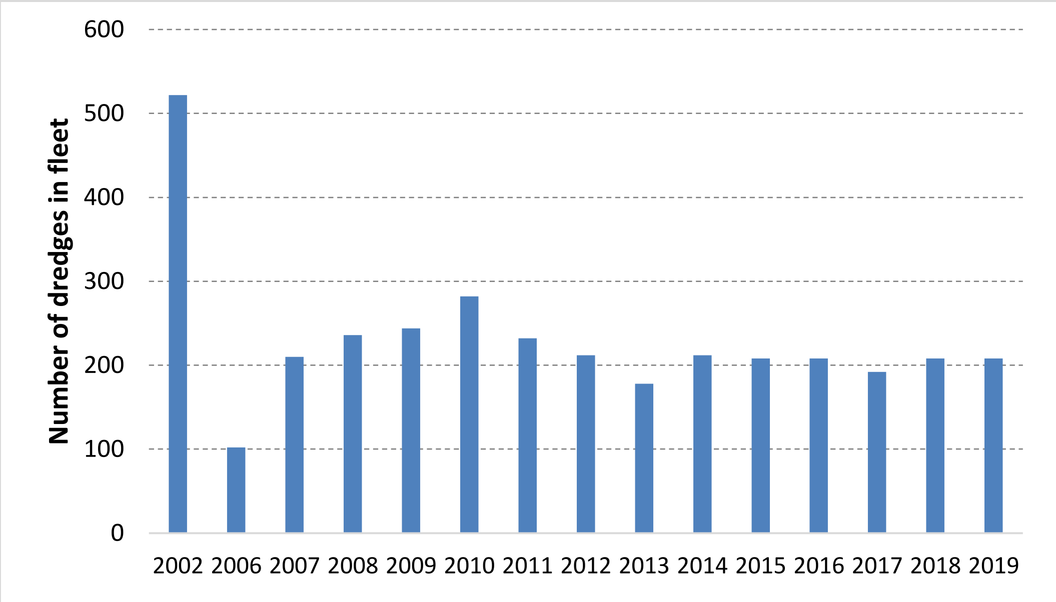


Figure 63. Annual estimated number of dredges in the authorised Irish fleet of scallop vessels over 10 m, 2002 and 2006–2019 based on the relationship between vessel length and number of dredges (Dredges = 0.88 * Boat length). The fleet was partly decommissioned in 2006.

9.5 Offshore scallop fisheries

9.5.1 Landings

Landings increased from 1995–2004 due to fleet expansion of the geographic areas fished, particularly in the Celtic Sea (Figure 64). The fleet also began to target scallop in the north east Irish Sea around the Isle of Man and in the Western Approaches to the English Channel. The fleet was partly decommissioned in 2006 and restricted in capacity thereafter and landings consequently declined. New vessels entered the fleet after 2006 and landings increased to an all-time high by 2013. Total landings have remained above 2,000 tonnes per annum since 2013 (Figure 64).

The Irish fleet fishes in the Celtic Sea, English Channel and the Irish Sea south of the Isle of Man (see Figure 62). The majority of landings are usually from the Celtic Sea, although the Eastern English Channel has become an increasingly important area for the fleet in recent years (Figure 65). The increase in landings from the Eastern English Channel since 2016 is correlated with a decline in landings from the Irish Sea in recent years (Figure 65).

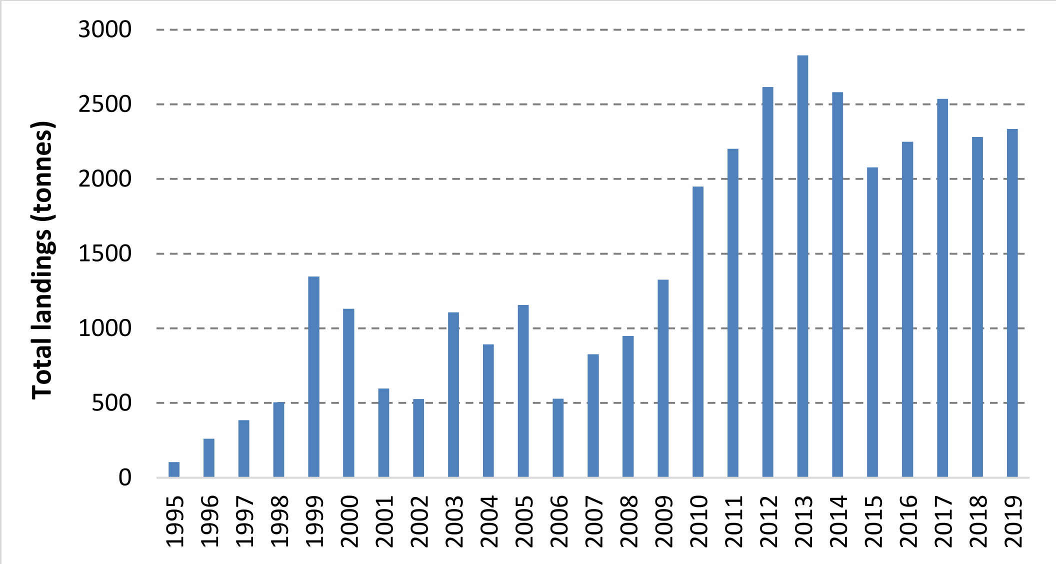


Figure 64. Annual landings of scallop by the Irish fleet 1995–2019.

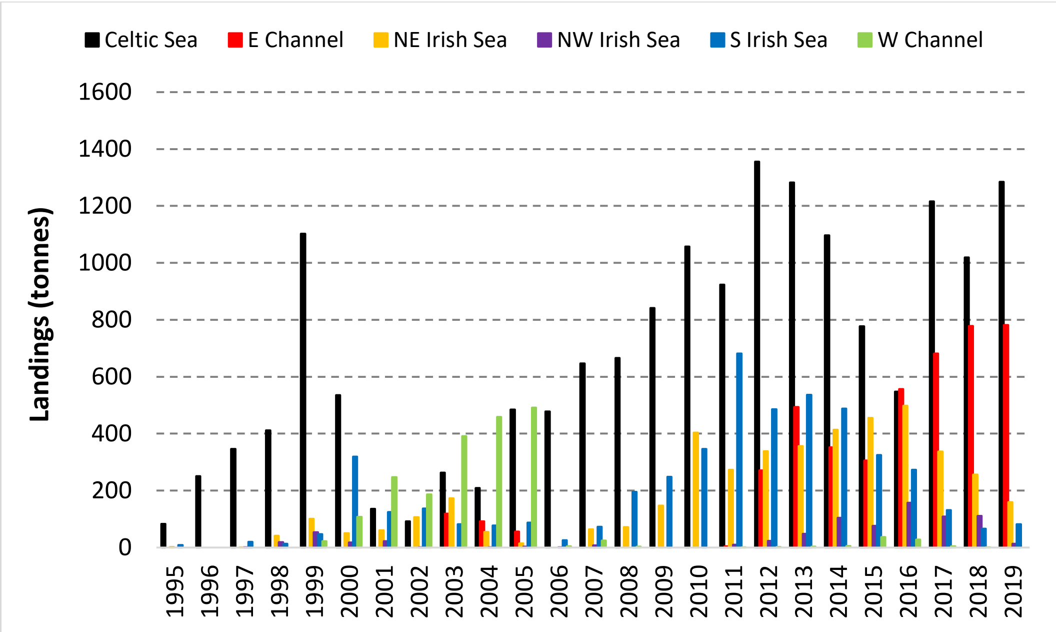


Figure 65. Annual landings of scallop by the Irish fleet from stocks in the Celtic Sea, Irish Sea and English Channel areas 1995–2019.

9.5.2 Catch rate indicators

In the Celtic Sea, catch rates ranged from 20–60 kgs.dredge^{-1}.day^{-1} up to 2006 and increased to 80 kgs.dredge^{-1}.day^{-1} from 2010–2012 (Figure 66). Generally, catch rates follow similar trends across the areas fished. Catch rates declined between 2010 and 2016 in most areas and fluctuated in 2017 and 2018. Catch rates declined substantially in the Western English Channel in 2018, although landings and effort in this area has been negligible since 2006. The most notable trend in recent years is from the Eastern English Channel where catch rates peaked at 160 kgs.dredge^{-1}.day^{-1} in 2016 (Figure 66) which is more than double that of any other area. The Irish fleet fish in this area during winter months (November–February), which was previously the time when the fleet targeted the north east Irish Sea area south of the Isle of Man. VMS data for 2019 was not yet available so catch rates couldn't be calculated.

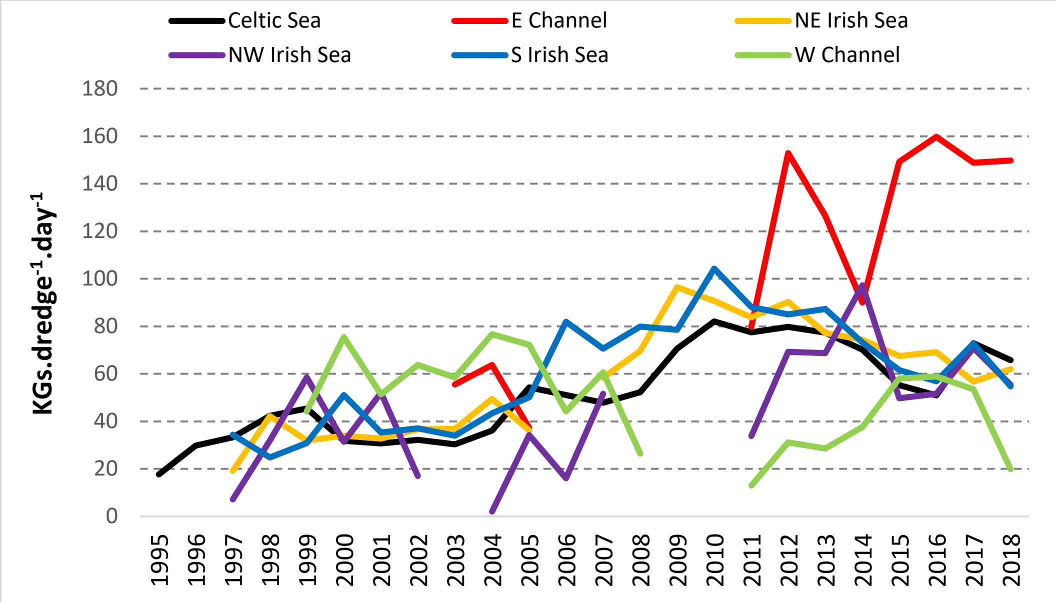


Figure 66. Annual average catch rate (kgs.dredge^{-1}.day^{-1}) from the main scallop stocks fished by the Irish fleet 1995–2018.

9.6 Scallop Surveys and Biomass Assessment

9.6.1 Celtic Sea Surveys 2018 and 2019

Surveys of the inshore and offshore scallop grounds were completed over 2018 and 2019 (funded by Ireland-Wales Interreg Bluefish project). Surveys were designed using VMS data from the Irish scallop fleet and classified acoustic backscatter data from multi-beam surveys of the seabed (www.infomar.ie). Ground-truthing through sediment sampling and camera surveys of the seabed had previously identified three principal ground types across the Celtic Sea scallop beds classified as: sand, coarse sediment/gravel and rock (Figure 67). Scallop surveys in the Celtic Sea in 2005 found a relationship between scallop density and ground type; densities were found to be approximately five times higher on coarse sediments compared to sand sediments. Due to this, 80 % of survey effort in the 2018/2019 survey was assigned to areas of coarse sediments compared to 20 % on sand sediments.

The inshore Celtic Sea, south of Waterford, was surveyed in 2018 on board an inshore commercial fishing vessel with 8 (4-a-side), 30-inch wide Newhaven spring-loaded dredges. In total, 49 tows of approximately 1,400 m length were completed over the course of 6 day trips: two in August and four in October 2018 (Figure 67). A size-weight relationship was estimated ashore and used in the biomass assessment.

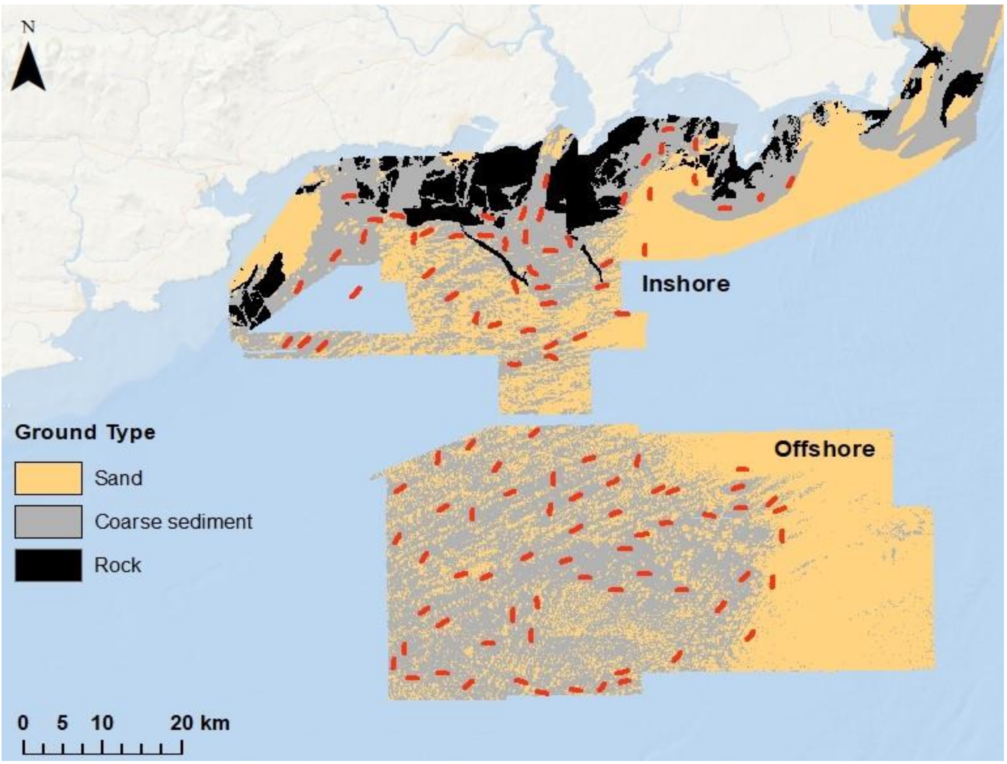


Figure 67. Location of tows carried out in the inshore (2018) and offshore (2019) Celtic Sea survey and the principal ground types in this area classified from multi-beam acoustic surveys.

The offshore area, also known as the B&H scallop ground, was surveyed over 5 days in July 2019 on board a commercial fishing vessel with 22 (11-a-side), 30-inch wide Newhaven spring-loaded dredges. In total, 60 tows were completed of approximately 1,400 m length (Figure 67). All scallop catch and bycatch was weighed and individually measured on board (see section 9.6.3 for bycatch details). In total 2,060 kg of scallop was caught and sampled during the offshore area survey.

Scallop biomass at each station was estimated as the product of density (i.e. number of individuals caught, m^{-2}) and mean weight calculated from the size distribution at each station and the weight-length relationship. Biomass was then interpolated over a 100 m x 100 m grid for the surveyed areas, and total biomass estimated using a geostatistical (kriging) model that accounts for the spatial structure of observed biomass and its autocorrelation relative to the distance between stations. Classified acoustic backscatter maps of ground type (see Figure 67) were used to inform the interpolation of biomass across the surveyed areas (co-kriging) in order to take into account the underlying relationship between scallop density and ground type.

Catchability (dredge selectivity and efficiency) was not estimated. Biomass estimates are therefore relative.

9.6.1.1 Size distribution and density

The size distribution of scallop catches from both the inshore (Figure 68) and offshore (Figure 69) Celtic Sea survey were similar, with the majority of scallop between 90 mm and 110 mm shell height, with a maximum size of approximately 120 mm observed in both areas. The observed densities were 0.0073 individuals per m^2 in the inshore Celtic Sea area (3,238 scallop/441,596 m^2), and 0.0083 individuals per m^2 in the offshore Celtic Sea area (11,838 scallop/1,418,952 m^2).

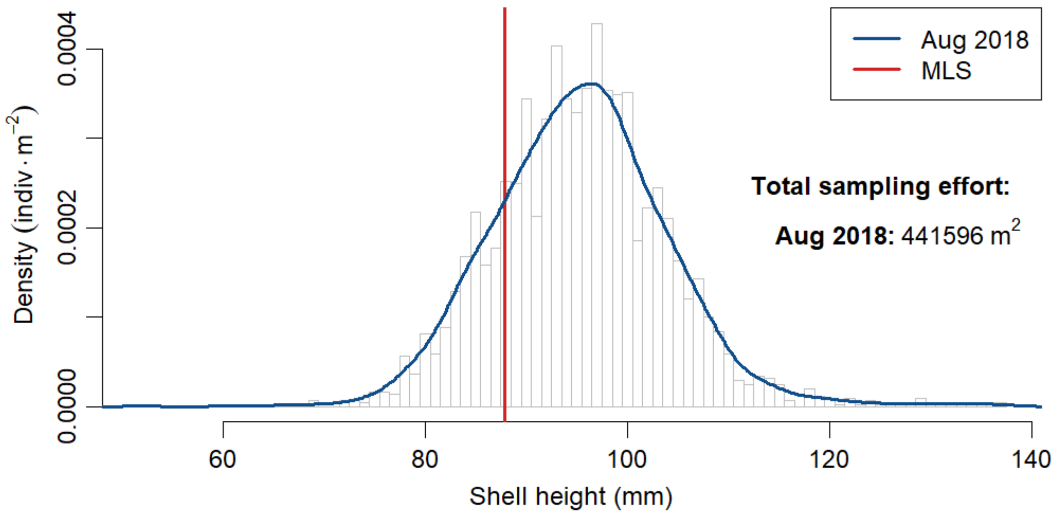


Figure 68. Size distribution and densities of scallop from the 2018 inshore Celtic Sea survey area. Vertical red line at 88 mm shell height corresponds to the MLS of 100 mm shell width in this area.

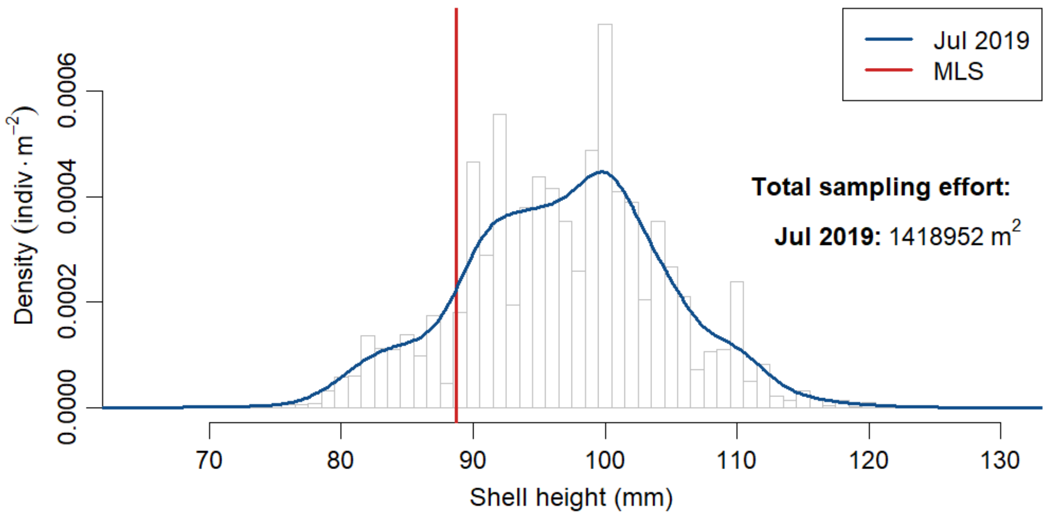


Figure 69. Size distribution and densities of scallop from the 2019 offshore Celtic Sea survey area. Vertical red line at 89 mm shell height corresponds to the MLS of 100 mm shell width in this area.

9.6.1.2 Biomass

In the inshore Celtic Sea survey area, total estimated biomass of scallop, without accounting for dredge efficiency and selectivity, was 605.7 tonnes, with 535.7 tonnes above MLS (Table 9-1). The estimated biomass of scallop was highest for large areas of coarse sediment south of Hook Head, Co. Wexford, and Brownstown Head, Co. Waterford (Figure 70). Estimated biomass of scallop was zero, or close to zero in areas of sand sediment, accurately reflecting the catches observed from these areas. The current lack of a complete inshore acoustic habitat map (see Figure 67) has prevented estimation of biomass for the entire inshore area (Figure 70).

Table 9-1. Estimates of scallop biomass (uncorrected for dredge efficiency) in the 2018 inshore Celtic Sea survey area.

	Biomass (tonnes)		95% confidence intervals	
	Mean	Median	Lower	Upper
Total Biomass	605.7	606.4	538.6	667.5
Biomass > MLS	535.7	531.2	476.1	582.6

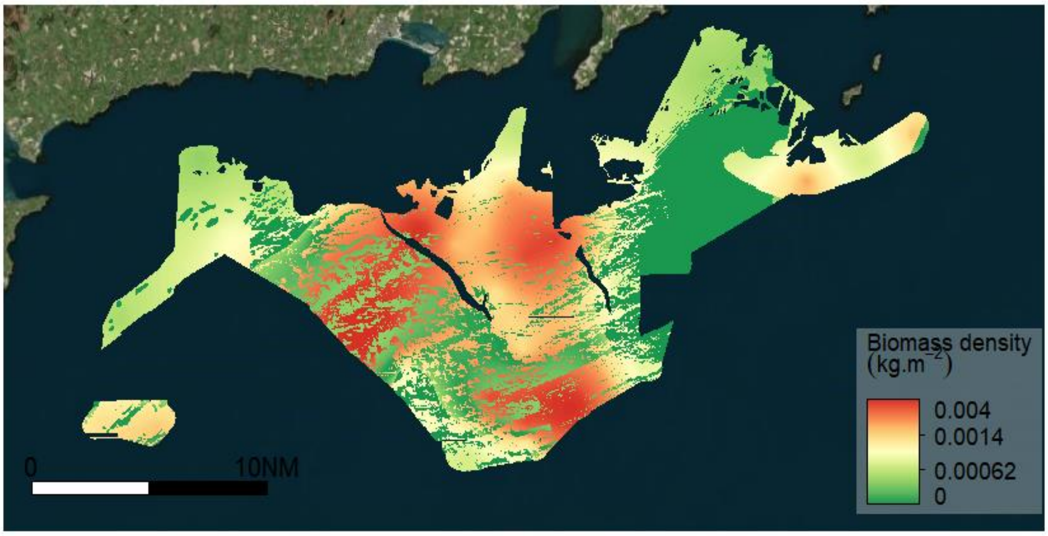


Figure 70. Spatial distribution of estimated total biomass of scallop (uncorrected for dredge efficiency) in the 2018 inshore Celtic Sea survey area.

In the offshore Celtic Sea survey area, total estimated biomass of scallop, with no correction for dredge efficiency or selectivity, was 1,654.6 tonnes, with 1,512.6 tonnes above MLS (Table 9-2). The estimated biomass of scallop was highest for areas of coarse sediment at the south and north-west of the survey area (Figure 71). Estimated biomass of scallop was also close to zero in areas of sand sediment. Results indicate scallops are distributed in areas that were not surveyed, particularly to the north-west and south of the current survey area.

Table 9-2. Estimates of scallop biomass (uncorrected for dredge efficiency) in the 2019 offshore Celtic Sea survey area.

	Biomass (tonnes)		95% confidence intervals	
	Mean	Median	Lower	Upper
Total Biomass	1,654.6	1,665	1,558.8	1,781
Biomass > MLS	1,512.6	1,530	1,428.1	1,631.2

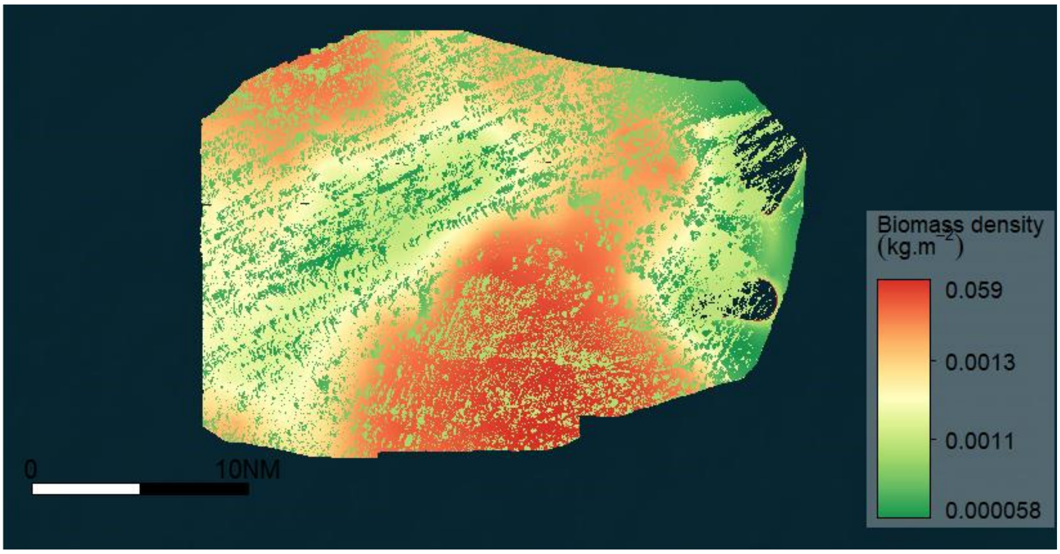


Figure 71. Spatial distribution of estimated total biomass of scallop (uncorrected for dredge efficiency) in the 2019 offshore Celtic Sea survey area. See Figure 67 for location of this survey area in relation to the Irish coast.

9.6.2 South Irish Sea (Tuskar & Barrels) Scallop Survey 2019

A scallop survey was carried out on the 19th and 20th September 2019 in an area to the west and south-west of Carnsore Point, Co. Wexford; known locally as the Barrels scallop bed, it is located in St. Georges Channel. The Tuskar scallop bed in the south Irish Sea off the east coast of Co. Wexford was later surveyed on the 21st and 22nd October 2019. The survey was carried out onboard a commercial fishing vessel using 22 (11-a-side), 30-inch-wide Newhaven spring-loaded dredges. The survey area was defined using 2014 to 2016 VMS data from the Irish scallop fleet (scallop fishing has been negligible in this area in recent years). Tows of approximately 1,300 m length were successfully carried out at 48 stations across the survey area, with all catch and bycatch weighed and individually measured (see section 9.6.3 for bycatch details). In total, 1,129 kg of scallop was caught and sampled.

Scallop biomass at each station was estimated from the product of density (i.e. number of individuals caught per m^2 of the area fished) and the mean individual weight calculated from the size distribution at the station and a weight-length relationship. Biomass was then interpolated over a 200 m x 200 m grid for the entire survey area, and total biomass estimated using a geostatistical (kriging) model that accounts for the spatial structure of observed biomass and how density changes relative to the distance between stations.

9.6.2.1 Size distribution and density

The size distribution of scallop in the south Irish Sea was mainly between 100 and 130 mm shell height (Figure 72). The observed scallop density across the entire survey area was 0.0039 individuals per m^2 (4,145 scallop/1,074,546 m^2). Density offshore in the Celtic Sea in the same year was 0.0083 individuals per m^2. The substantial drop-off in numbers of scallop below 100 mm shell height indicate a lack of recruitment in this area in recent years, particularly for the northern end of the survey area. An ongoing genetics study of scallop populations in the south Irish Sea and Celtic Sea, in collaboration with Aberystwyth University, will provide information as to whether this population is genetically isolated, or if it relies upon larval supply from other areas.

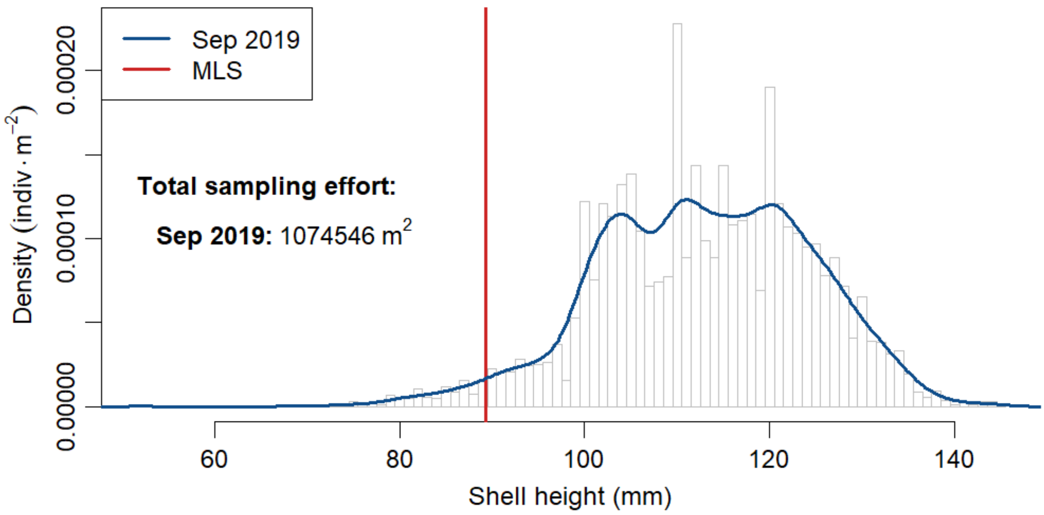


Figure 72. Size distribution and densities of scallop from the 2019 south Irish Sea survey area. Vertical red line at 89 mm shell height corresponds to the MLS of 100 mm shell width.

9.6.2.2 Biomass

In the south Irish Sea survey area, the total biomass of scallop, without accounting for catchability, was estimated to be 1,287 tonnes, with 1,277 tonnes estimated to be above MLS (Table 9-3). The biomass of commercial size scallop, therefore, comprises 99.2 % of the total stock biomass estimated to be present in the surveyed area. In the survey area, biomass is highest in the Barrels area and patches of the Tuskar area east of Cahore Point, Co. Wexford (Figure 73).

Interpolated estimates of distribution indicate that areas with potential scallop biomass were not surveyed (Figure 73) given high densities at the edge of the survey domain.

Table 9-3. Estimates of scallop biomass (uncorrected for dredge efficiency) in the 2019 south Irish Sea survey area.

	Biomass (tonnes)		95% confidence intervals	
	Mean	**Median**	**Lower**	**Upper**
Total Biomass	1,287	1,284	1,097	1,472
Biomass > MLS	1,277	1,278	1,107	1,481
Biomass > 120 mm	1,062	1,067	922	1,242

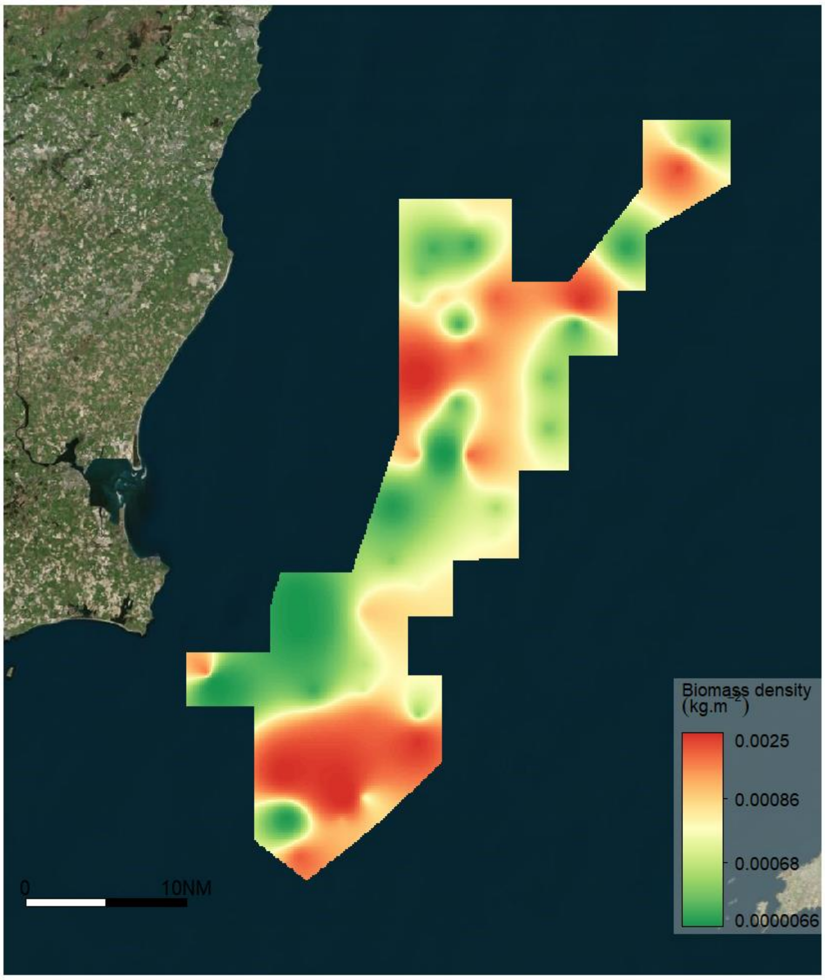


Figure 73. Spatial distribution of estimated total biomass of scallop (uncorrected for dredge efficiency) in the 2019 south Irish Sea survey area.

9.6.2.3 Age Structure

Compared to scallop from the Celtic Sea, clearer growth marks were evident on shells from the south Irish Sea (Figure 74). Growth rates were highest at Carnsore followed by the Tuskar and Barrels grounds (Figure 75).

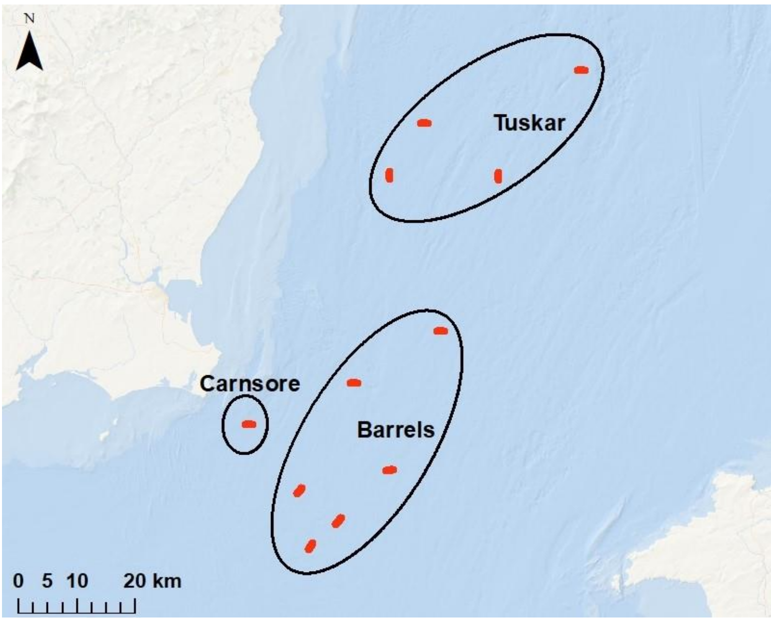


Figure 74. Location of tows and areas from which scallop were sampled for age during the 2019 south Irish Sea survey.

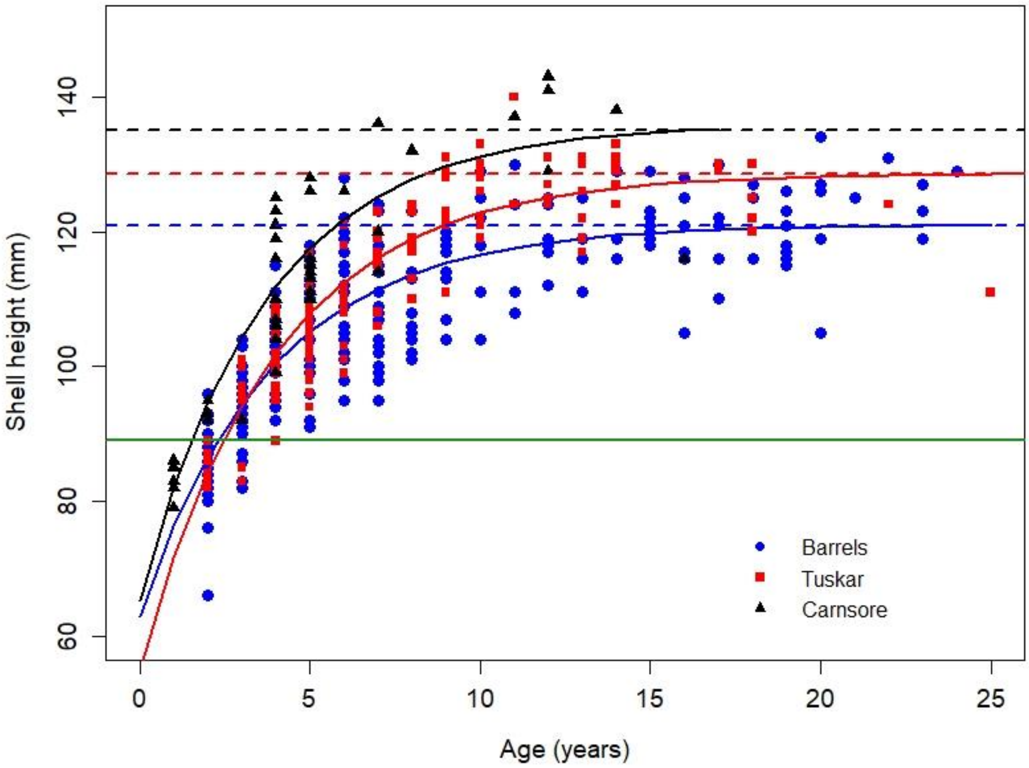


Figure 75. Size-at-age distribution of scallop sampled from the Tuskar (N = 174), Barrels (N = 260) and Carnsore (N = 40) areas. Solid lines are von Bertalanffy growth curves fitted to the size-at-age data. Dashed horizontal lines indicate the asymptotic scallop size for each area. Solid green line at 89 mm corresponds to the MLS of 100 mm shell width.

9.6.3 Bycatch Celtic Sea and South Irish Sea

In the inshore Celtic Sea area surveyed in 2018, monkfish (*Lophius piscatorius*), brown crab (*Cancer pagurus*) and spider crab (*Maja brachydactyla*) were the most common bycatch species (Figure 76). In the offshore Celtic Sea area surveyed in 2019, monkfish, brown crab and spotted ray (*Raja montagui*) were common. In the south Irish Sea spider crab, spotted ray, blonde ray (*Raja brachyura*) and lesser-spotted dogfish (*Scyliorhinus canicula*) were the most common bycatch species. Catches of elasmobranch species was highest in the south Irish Sea, with catches of flatfish species such as thickback sole (*Microchirus variegatus*) and megrim (*Lepidorhombus whiffiagonis*) more common in the offshore Celtic Sea and plaice (*Pleuronectes platessa*) in the inshore Celtic Sea. Brown crab were common in the Celtic Sea areas but not the South Irish Sea, and spider crab were common in the inshore Celtic Sea and south Irish Sea but not the offshore Celtic Sea.

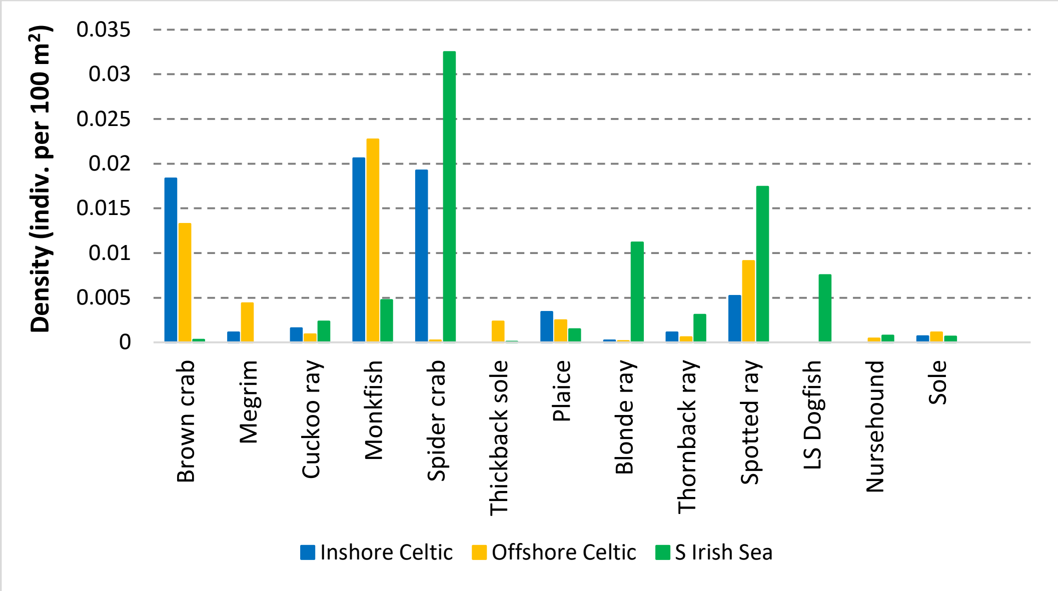


Figure 76. Densities of the main bycatch species from the Celtic Sea and south Irish Sea surveys.

9.6.4 Comharchumann Sliogéisc Chonamara (Galway) Surveys 2019

A survey was carried out on the 5th November 2019 on the main scallop bed in Beirtreach Buí Bay, and on the 13th & 21st November 2019 on the scallop beds of Cill Chiaráin and Caisín Bays, Co. Galway. A total of 50 tows were completed using 3 x 0.75 m wide spring-loaded scallop dredges in Cill Chiaráin and Caisín Bays, and 42 tows using a single toothed dredge of width 1.20 m in Beirtreach Buí Bay. Scallop catch and bycatch were recorded, weighed and measured on board from each tow. These surveys are a follow-on from surveys previously carried out by the Marine Institute in Cill Chiaráin and Caisín Bays in December 2018, and in Beirtreach Buí Bay in January 2019.

9.6.4.1 Cill Chiaráin Bay

The size distribution of scallop recorded in Cill Chiaráin Bay during the survey shows two strong peaks at about 110 mm and 120 mm shell height (Figure 77).

Total estimated biomass of scallop, not accounting for catchability, was estimated to be 76.74 tonnes (Table 9-4). The biomass of scallop above the local minimum landing size (MLS) of 120 mm shell width, equivalent to 104 mm shell height was estimated to be 65.89 tonnes (Table 9-4). These biomass estimates are substantially greater than the total of 39.2 tonnes estimated to be present during the December 2018 which covered a similar total survey area. The difference is most likely to be due to different dredge efficiencies occurring between surveys.

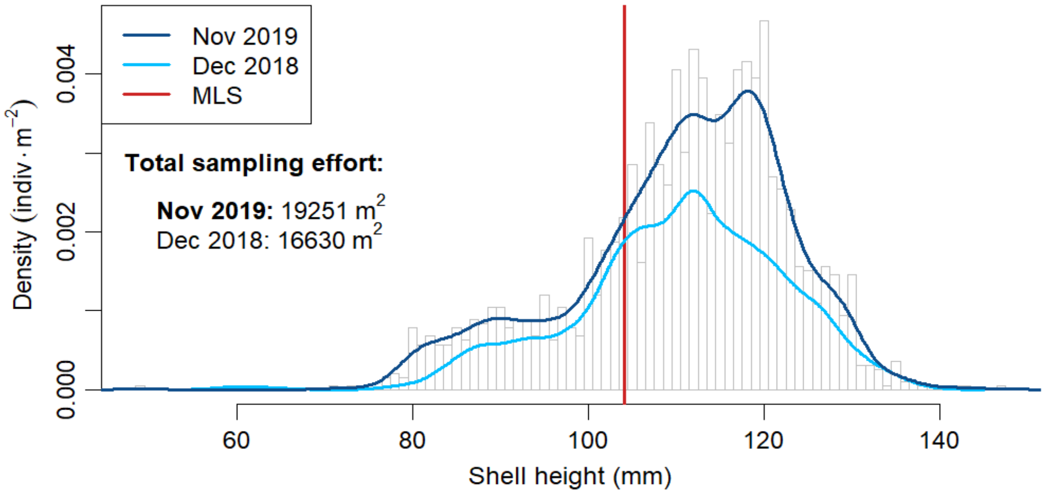


Figure 77. Size distribution and densities of scallop from the November 2019 Cill Chiaráin Bay raw survey data. Vertical red line at 104 mm shell height corresponds to the Comharchumann Sliogéisc Chonamara MLS of 120 mm shell width. The size distribution of scallop recorded during the December 2018 survey in Cill Chiaráin Bay are included for comparison purposes.

Table 9-4. Estimates of scallop biomass (uncorrected for dredge efficiency) in the November 2019 Cill Chiaráin Bay survey area.

	Biomass (tonnes)		95% confidence intervals	
	Mean	Median	Lower	Upper
Total Scallop Biomass	76.74	77.34	64.04	89.62
Scallop Biomass > MLS 120 mm	65.89	65.60	54.27	76.72

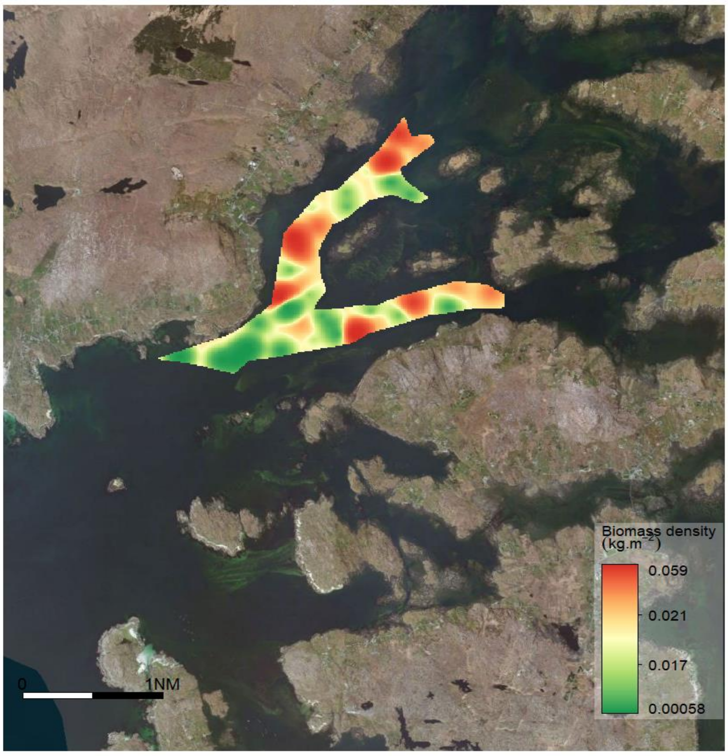


Figure 78. Total biomass distribution of scallop (uncorrected for dredge efficiency) in the 2019 Cill Chiaráin Bay survey area.

9.6.4.2 Caisín Bay

The size distribution of scallop recorded in Caisín Bay during the survey showed two peaks at about 98 mm and 110 mm shell height (Figure 79).

The total biomass of scallop, without accounting for catchability, was estimated to be 10.25 tonnes (Table 9-5). The biomass of scallop above the Comharchumann Sliogéisc Chonamara MLS of 120 mm shell width, equivalent to 104 mm shell height was estimated to be 5.62 tonnes (Table 9-5).

Table 9-5. Estimates of scallop biomass (uncorrected for dredge efficiency) in the November 2019 Caisín Bay survey area.

	Biomass (tonnes)		95% confidence intervals	
	Mean	Median	Lower	Upper
Total Scallop Biomass	10.25	10.24	7.38	13.88
Scallop Biomass > MLS 120 mm	5.62	5.64	4.59	6.85

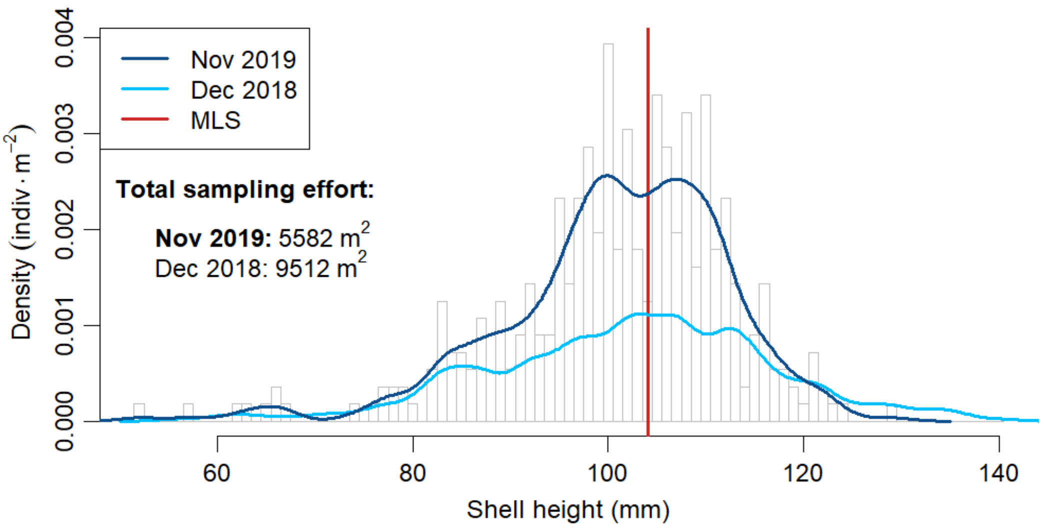


Figure 79. Size distribution and densities of scallop from the November 2019 Caisín Bay raw survey data. Vertical red line at 104 mm corresponds to the Comharchumann Sliogéisc Chonamara MLS of 120 mm shell width. The size distribution of scallop recorded during the December 2018 survey in Caisín Bay are included for comparison purposes.

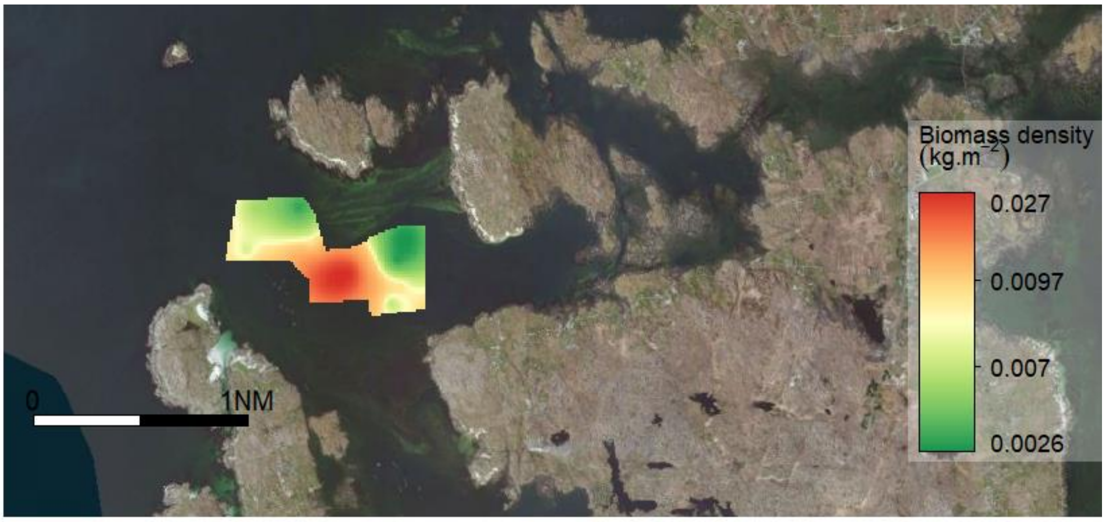


Figure 80. Total biomass distribution of scallop (uncorrected for dredge efficiency) in the November 2019 Caisín Bay survey area.

9.6.4.3 Beirtreach Buí Bay

The size distribution of scallop recorded in Beirtreach Buí Bay during the survey showed two peaks at about 110 mm and 120 mm shell height (Figure 81). Some scallop < 60 mm shell height were caught.

In Beirtreach Buí Bay the total biomass of scallop, without accounting for catchability, was estimated to be 7.03 tonnes (Table 9-6). The biomass of scallop above the Comharchumann Sliogéisc Chonamara MLS of 120 mm shell width, equivalent to 105 mm shell height was estimated to be 5.8 tonnes (Table 9-6). These biomass estimates are comparable to the total of 7.49 tonnes and 5.4 tonnes of commercial sized scallop biomass estimated to be present during the December 2018 survey in this area.

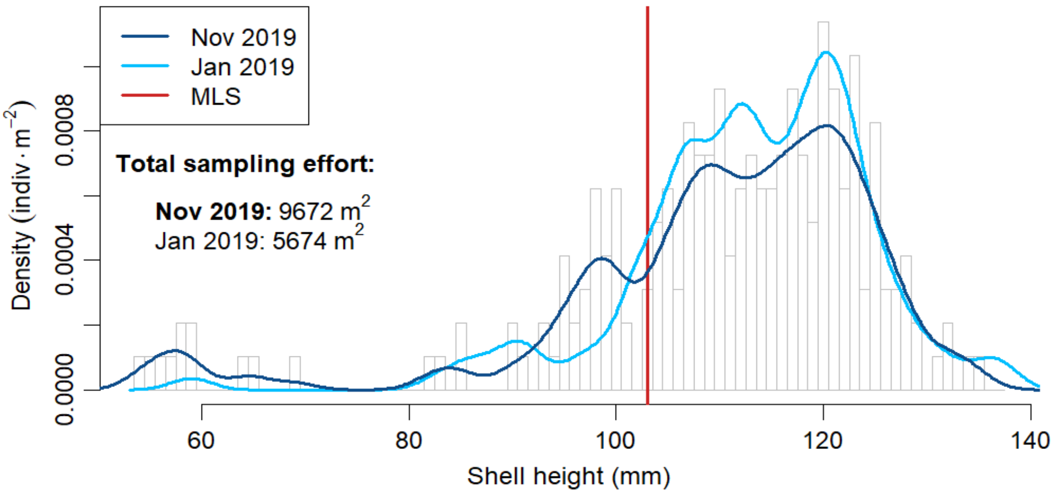


Figure 81. Size distribution and densities of scallop from the November 2019 Beirtreach Buí Bay raw survey data. Vertical red line at 105 mm corresponds to the Comharchumann Sliogéisc Chonamara MLS of 120 mm shell width. The size distribution of scallop recorded during the January 2019 survey in Beirtreach Buí Bay are included for comparison purposes.

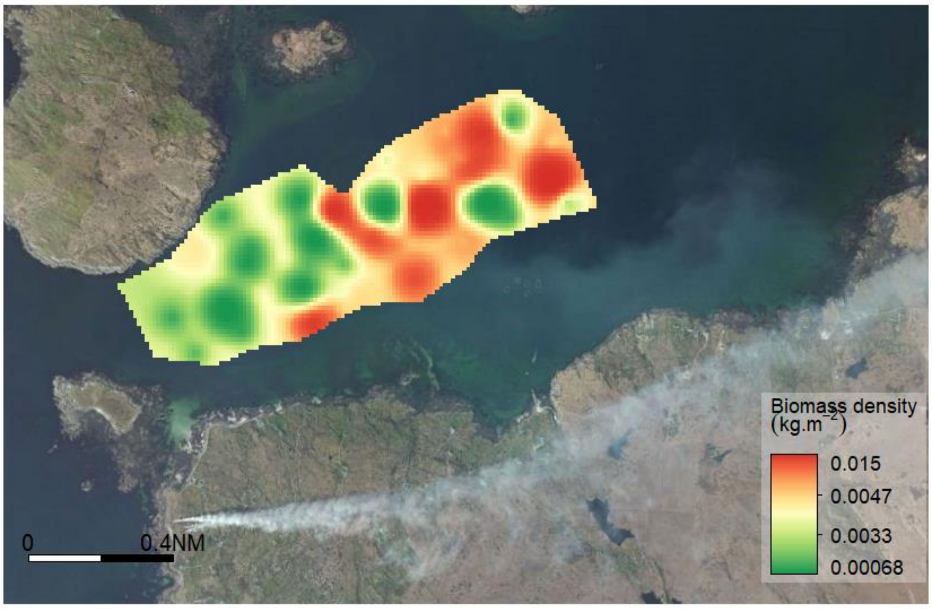


Figure 82. Total biomass distribution of scallop (uncorrected for dredge efficiency) in the November 2019 Beirtreach Buí Bay survey area.

Table 9-6. Estimates of scallop biomass (uncorrected for dredge efficiency) in the November 2019 Beirtreach Buí Bay survey area.

	Biomass (tonnes)		95% confidence intervals	
	Mean	**Median**	**Lower**	**Upper**
Total Scallop Biomass	7.03	7.21	5.54	9.19
Scallop Biomass > MLS 120 mm	5.80	6.01	4.57	7.67

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.

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). Also referred to as a metier.

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).

Growth overfishing Reduced yields of fish due to reduction in average size/weight/age caused by fishing mortality and indicating that the rate of fishing is higher than the rate at which fish grow to given sizes to replace those being removed

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

V-notch A conservation measure used in lobster fisheries in Ireland and elsewhere whereby lobsters marked with a v-notch are protected from fishing