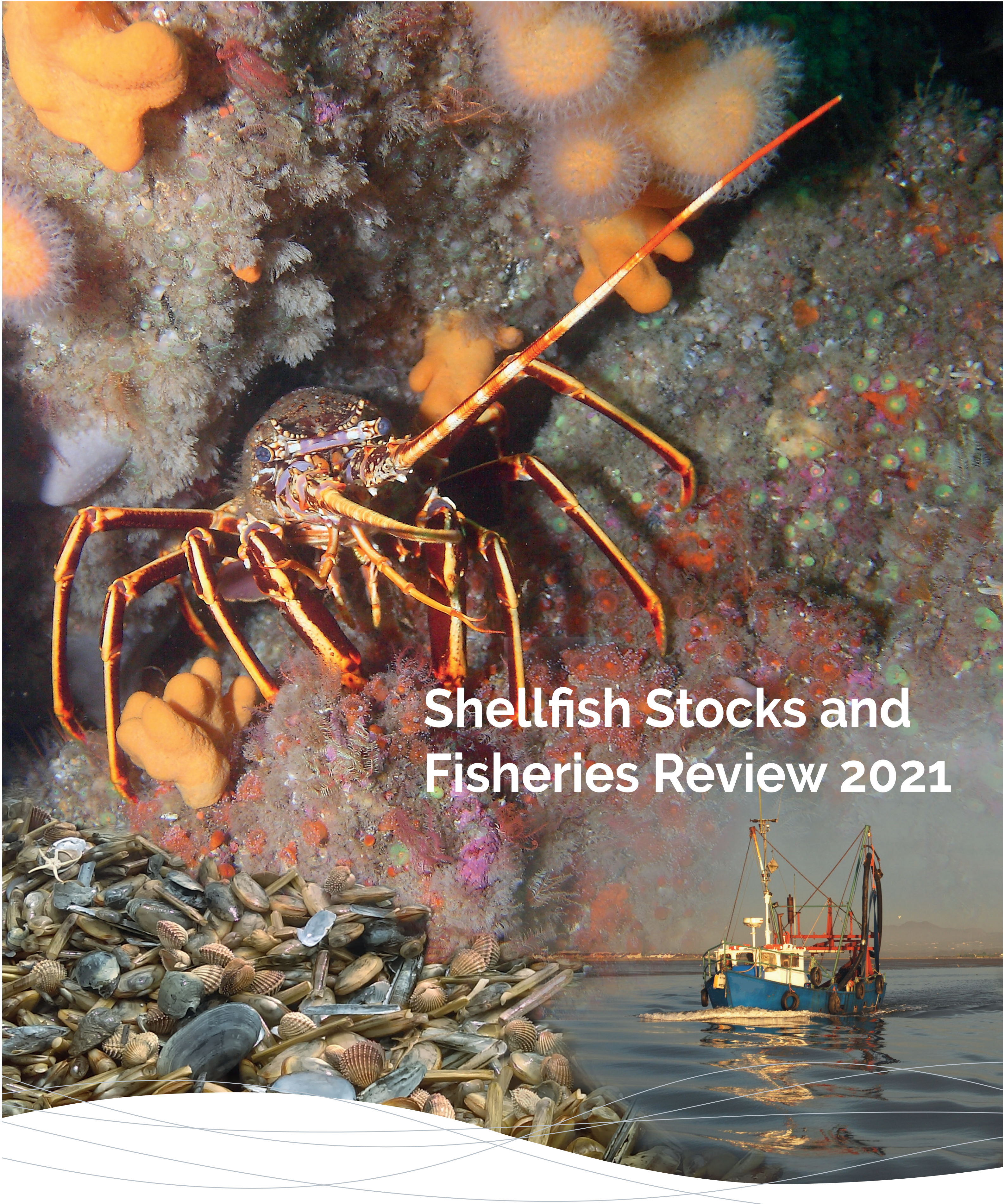

Shellfish Stocks and Fisheries Review 2021

BIM Ireland's Seafood Development Agency

Foras na Mara
Marine Institute

Shellfish Stocks and Fisheries

Review 2021

An assessment of selected stocks

The Marine Institute and Bord Iascaigh Mhara

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

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 Jonathan White (Crayfish – Palinurus elephas), Macdara O Cuaig (Catch from fishing razor clams) and Sarah Clarke (Cockle boat)

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Contents

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, 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 Environment, Climate and Communications, 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 Registered Fishing Fleet

2.1 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 which 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 Gross Tonnes (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. 28/2018 (http://agriculture.gov.ie/fisheries/).
(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. 28/2018
(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.

2.2 Fleet capacity

The total registered capacity of the Irish fishing fleet, as of December 2021, was 66,595 gross tonnes (GTs) and 1,994 vessels. The polyvalent general segment included 31,992 GTs and 1,388 vessels. The polyvalent potting segment had 330 registered vessels and 694 GTs while the bivalve (specific) segment, including scallop vessels, had 2,231 GTs and 146 vessels. There were 10 beam trawl vessels, 10 scallop vessels over 10 m in the specific segment and 3 in the polyvalent segment and 23 RSW pelagic vessels (Table 1).

The total number of registered vessels in the fleet peaked in 2012 at 2,212 vessels which was 218 vessels more than in 2021.

In 2021 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-four percent of polyvalent potting vessels were less than 10 m in length and all were under 12 m. Approximately 55 % of the specific fleet of 134 vessels were under 10 m.

Table 1. Number of vessels by length category in each segment of the Irish sea fishing fleet in December 2021.

Segment	10-12m	12-15m	15-18m	O18m	U10m	Total
Aquaculture	6	1	1	16	73	97
Beamer				10		10
Polyvalent [<18m LOA]	147	60	20		1,025	1,252
Polyvalent [>=18m LOA]				133		133
Polyvalent [Potting]	18				312	330
Polyvalent [Scallops >=10m LOA]	2	1				3
RSW Pelagic				23		23
Specific	54	5		2	75	136
Specific [Scallops >=10m LOA]	2	1		7		10
Grand Total	**229**	**68**	**21**	**191**	**1,485**	**1,994**

2.3 Fleet capacity transfer rules

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. Capacity attached to vessels under 18 m cannot be transferred to vessels over 18 m and vice versa.
(2) Excluding the fisheries licenced by secondary authorisation 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. When it is no longer attached to a registered vessel it is negated.
(5) Polyvalent general capacity that is not attached to a registered vessel for a period of more than 2 years expires.

2.4 Vessels targeting Shellfish

The shellfish fleet is here defined as vessels under 13 m in length, as the vast majority of such vessels depend largely on shellfish. This cut off, however, is not reflective of any licencing or policy condition and many of these vessels also fish for other species. In addition, a number of vessels over 18 m target crab mainly in offshore waters (vivier vessels) and 13 vessels over 10 m in length were authorised to fish for scallops in 2021.

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 polyvalent potting segment was established at this time. The number of vessels in this segment is declining year on year due to de-registration and movement of vessel into the polyvalent general segment. There were 330 such vessels in 2021 compared to 490 in 2007. The number of vessels in the polyvalent general segment increased year on year between 2006 and 2012 but numbers declined overall from 2012-2021 (Table 2, Table 3, Figure 1).

Table 2. Length and capacity profile of the Irish shellfish fleet 2006-2020 (<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	1081	482	115	1,724
2009	60	1146	474	124	1,804
2010	68	1198	467	120	1,853
2011	78	1239	461	118	1,896
2012	85	1269	460	122	1,936
2013	86	1233	454	117	1,890
2014	89	1218	448	112	1,867
2015	89	1226	426	123	1,864
2016	87	1218	404	126	1,835
2017	83	1171	363	125	1,742
2018	84	1200	337	138	1,759
2019	80	1204	330	136	1,750
2020	79	1204	329	127	1,739
2021	80	1201	330	132	1,743
Average Length (m)					
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	7.05	7.54	6.61	9.59	7.50
2020	7.07	7.53	6.62	9.55	7.48
2021	7.06	7.54	6.60	9.63	7.49

Table 2. continued

Year	Aquaculture	Polyvalent General	Polyvalent Potting	Specific	Total
Average GTs					
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	2.84	3.92	2.12	7.52	3.81
2020	2.85	3.89	2.12	7.19	3.75
2021	2.83	3.89	2.10	7.51	3.78
Average KWs					
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	31.62	30.26	29.02	66.63	32.91
2020	31.78	29.99	28.94	64.13	32.37
2021	31.56	30.16	28.87	67.06	32.77

Table 3. Annual change and percentage change in the numbers of vessels per fleet segment in the under 13 m Shellfish fleet 2006-2020.

Years	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
2017-2108	1	29	-26	13	17
2018-2109	-4	4	-7	-2	-9
2019-2020	-1	0	-1	-9	-11
2020-2021	1	-3	1	5	4
% change in number of vessels					
2006-2007	333	5	513	-4	41
2007-2008	254	8	-2	24	8
2008-2009	30	6	-2	8	5
2009-2010	13	5	-1	-3	3
2010-2011	15	3	-1	-2	2
2011-2012	9	2	0	3	2
2012-2013	1	-3	-1	-4	-2
2013-2014	3	-1	-1	-4	-1
2014-2015	0	1	-5	10	0
2015-2016	-2	-1	-5	2	-2
2016-2017	-5	-4	-10	-1	-5
2017-2108	1	2	-7	10	1
2018-2109	-5	0	-2	-1	-1
2019-2020	-1	0	0	-7	-1
2020-2021	1	0	0	4	0

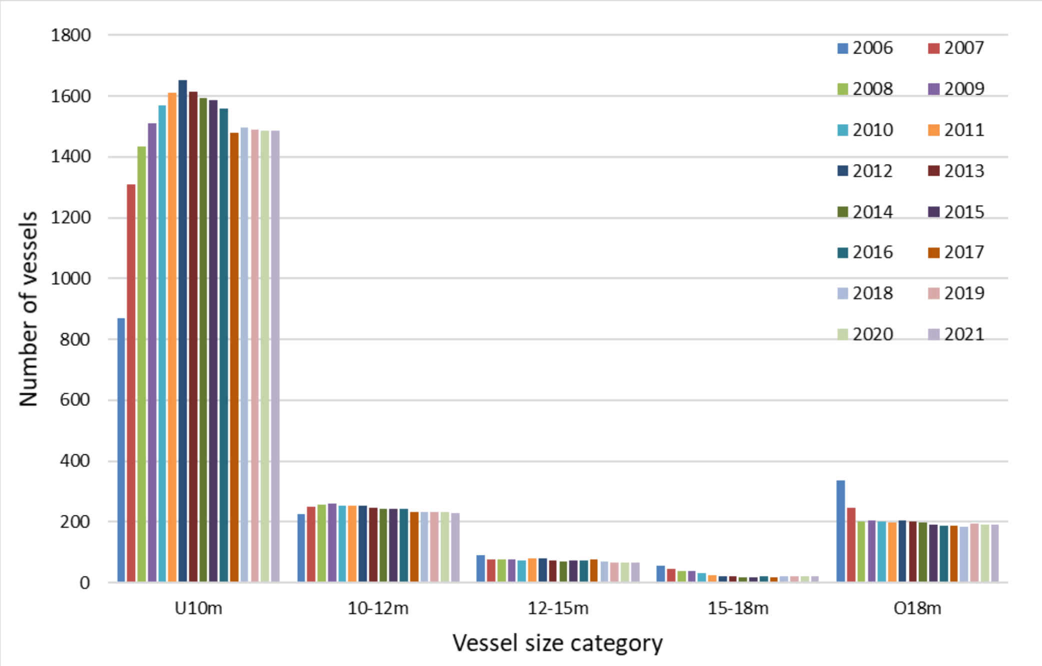

Figure 1. Annual trends in the number of registered sea fishing vessels by length category 2006-2021.

3 Shellfish Landings 2004-2021

Annual landings of crustaceans and bivalves, excluding *Nephrops* and wild blue mussel (*Mytilus*) seed, which is re-laid for on-growing, landed into Ireland by Irish vessels during the period 2004-2021, varied from a high of 29,000 tonnes in 2004 to a low of 13,790 in 2009. Landings were just under 18,000 tonnes in 2021 (Table 4). Data in Table 4 has been reviewed, relative to previous annual reports, based on updated logbook and sales note data and also by excluding landings by Irish vessels if they are not landed into Ireland.

A number of species such as lobster, 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 data collected under the buyers and sellers of first sale fish regulation which obliges buyers to log the purchase of fish at the first point of sale from a fishing vessel.

Landings data for certain species that are subject to management plans (cockle), that are managed locally (oysters) or where SFPA have digitised shellfish registration dockets and consignment data to buyers (cockles, razor clams) provide additional data on landings separate to logbook data or sales notes.

Total value of shellfish landings, excluding mussel and *Nephrops*, in 2021 was €57.7 million compared to €53.4 million in 2020.

The total engaged crew in dredging (bivalves) and potting (crustaceans, whelk) vessels under 12m in length declined from 1381 in 2016 to 1090 in 2020. The number of full time equivalent jobs increased from 865 to 1037 during the same period. This may indicate an increase in the prevalence of sole operators working in these fisheries. The number of active vessels, or vessels making sales in a given year, ranged from 824-891 during the period 2016-2020.

Table 4. Estimates of annual landings (tonnes) and value (€) of crustacean and bivalve shellfish (excl. prawns and mussels) by Irish vessels into Ireland 2004-2021 (source: Logbook declarations and sales notes for vessels under 10 m, shellfish registration dockets, co-op data). Unit value (per kilo) is from sales note data or other sources.

Year	Edible crab	King Scallop	Lobster	Periwinkle	Whelk	Shrimp	Native oyster	Queen scallop	Velvet crab	Surf clam	Spider crab	Crayfish	Razor clams	Shore crab	Cockle	Total tonnage
2004	13,119	2,421	855	1,674	2,600	416	543	110	291	28	182	80	401	266	207	23,193
2005	9,413	1,229	644	1,139	4,154	153	94	75	253	0	146	31	404	27	107	17,867
2006	9,248	644	611	1,210	2,917	312	233	172	270	5	151	34	507	46	7	16,368
2007	7,158	917	297	609	2,644	324	291	28	138	14	66	16	339	91	643	13,575
2008	7,029	1,217	498	1,141	2,097	180	88	4	260	34	148	20	456	72	9	13,254
2009	5,525	2,610	423	1,103	2,163	224	327	3	204	26	443	28	229	233	173	13,712
2010	8,093	1,959	470	1,280	2,975	134	349	0	342	25	414	30	443	129	5	16,649
2011	6,825	2,612	250	64	3,174	111	100	0	184	36	303	25	523	74	401	14,682
2012	6,115	2,621	244	103	3,446	148	100	12	169	16	402	35	465	253	400	14,528
2013	6,227	2,797	367	218	2,628	172	214	134	366	37	228	34	852	30	374	14,679
2014	6,953	2,597	445	1,135	2,180	289	265	80	231	67	137	23	903	50	3	15,358
2015	6,900	2,077	363		5,014	295	153	31	202	49	193	14	1,265	23	0	16,579
2016	9,332	2,237	402		5,822	363	190	201	277	51	161	10	1,127	165	321	20,658
2017	9,086	2,580	415		4,977	281	168	7	313	45	143	10	961	127	442	19,553
2018	8,167	2,301	345		4,638	272	150	4	213	47	119	9	1041	118	446	17,870
2019	8,095	2,345	488		5,090	430	150	3	253	44	425	30	783	288	595	19,020
2020	6,406	1,940	437		5,302	343		1	240	12	451	15	672	154	1,152	17,126
2021	6,644	2,739	482		4,938	338	250	0	263	0	477	49	595	391	638	17,802
Unit price 2021	€2.22	€4.19	€18.62	€3.60	€1.50	€20.55	€4.50	€0.00	€2.14	€0.00	€0.57	€35.23	€5.34	€0.55	€1.80	
Value 2021 (millions)	€14.75	€11.48	€8.97	€0.00	€7.41	€6.95	€1.13	€0.00	€0.56	€0.00	€0.27	€1.73	€3.18	€0.22	€1.16	**€57,7870**

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. The number of v-notched lobsters released annually was 5,000-11,000 individuals during 2002-2008, 10,000-15,000 during 2010-2013 and 25,000-33,000 annually during 2014-2021.

In 2021 observer data showed that lobsters below 87 mm accounted for 19 % of reproductive potential (RP), lobsters in the fishable size range accounted for 50 % and v-notched lobsters in that size range accounted for 20 % of RP. The remainder of RP was in lobsters over 127 mm (8.5 % in v-notched lobsters over 127 mm and 1.5 % in lobsters over 127 mm that are not v-notched). V-notched lobsters in 2021 contributed more RP than in the previous years; both in the 87-127 mm size range and also above the 127 mm maximum size limit. A combination of the MLS and MaxLS protects 29 % of RP and v-notching protects a further 20 %. Observer sampling coverage in 2021 was lower than in previous years.

Nominal stock status indicators, landings per unit effort, discards per unit of effort and v-notched lobsters per unit of effort were stable during the period 2013-2021 in most coastal areas. The index of undersized lobsters increased from 2015-2017 and was stable in 2017-2021.

Conservation measures should be maintained. The MaxLS is a size refuge for lobsters that have previously been v-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. Uptake 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.

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, from the sentinel vessel programme (SVP) and since 2021 from a Skipper self-sampling 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 SVP, which covers approximately eight percent of the fleet, from the Skipper self-sampling programme and from the MI observer programme. This coverage is still insufficient to provide precise estimates of catch rates at local level given the variability in these data in time and space.

4.3 Management units

Lobsters are probably distributed as regional stocks along the Irish coast. This has been shown by 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 is no limit on fishing effort or catch.

4.5 Contribution of conservation measures to reproductive potential

4.5.1 Implementation of the v-notched programme

From 2002 to 2008 between 5,000 and 11,000 lobsters were released annually. This increased to between 10,000 and 15,000 during the period 2010 to 2013. From 2014-2018 releases increased to between 25,000 and 32,000 annually but were lower in 2019 and 2020. Record numbers of 33,904 lobsters were released in 2021 although the overall weight was lower than in 2017 and 2018 (Figure 2).

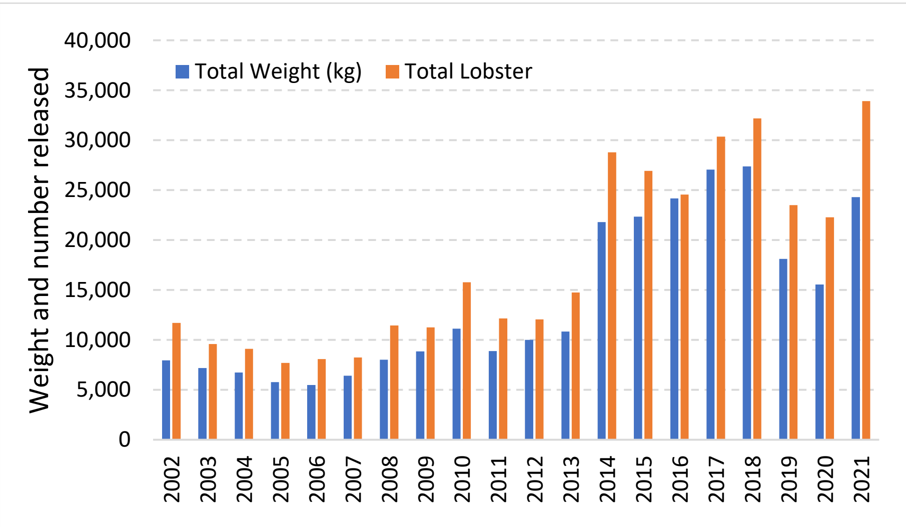

Figure 2. Total number and weight of V-Notched lobsters releases 2002-2021.

4.6 Reproductive potential

The reproductive potential (RP) of a given size class of lobsters is the product of the number of lobsters in the size class, the probability of maturity, spawning frequency and size related fecundity. It is a measure of the relative contribution of different size classes and v-notched or non-v-notched components of the stock to overall reproduction. An indicator of the implementation and effect of the v-notch programme should be evidenced through changes in RP of the v-notch component of the stock relative to non-v-notched components. Similarly changes in RP of lobsters over the MaxLS may increase over time as lobsters' escape fishing mortality and grow above 127 mm.

On average across years 15-20 % of RP is in lobsters below the minimum landing size of 87 mm (Figure 3, Figure 4 and Figure 5). A further 50-60 % is in lobsters between 87-127 mm, which is the size range that is fished. V-notched lobsters generally account for 10-20 % of the RP. In 2021 observer data showed that lobsters below 87 mm accounted for 19 % of RP, lobsters in the fishable size range accounted for 50 % of RP, v-notched lobsters in that size range accounted for 20 % of RP and the remainder of RP was in lobsters over 127 mm (8.5 % in v-notched lobsters over 127 mm and 1.5 % in lobsters over 127 mm that are not v-notched). There are significantly higher contributions in 2021 by v-notched lobsters both in the 87-127 mm size range and also above the 127 mm maximum size limit. Observer data in 2021 is less comprehensive than in 2020 and some differences may be accounted for by poorer sampling coverage. The data from the new Skipper self-sampling programme established in 2021 have yet to be incorporated into these figures.

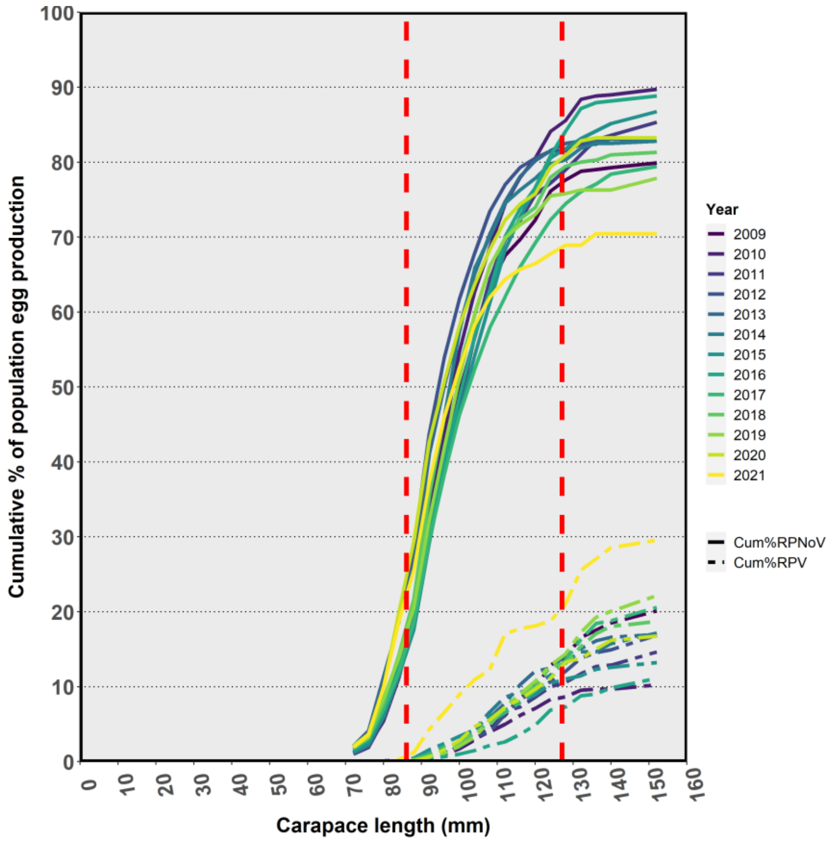

Figure 3. Cumulative distribution of reproductive potential (RP) across size classes of V-notched and non-V-notched lobsters all regions combined. Source: Marine Institute Observer data 2009-2021.

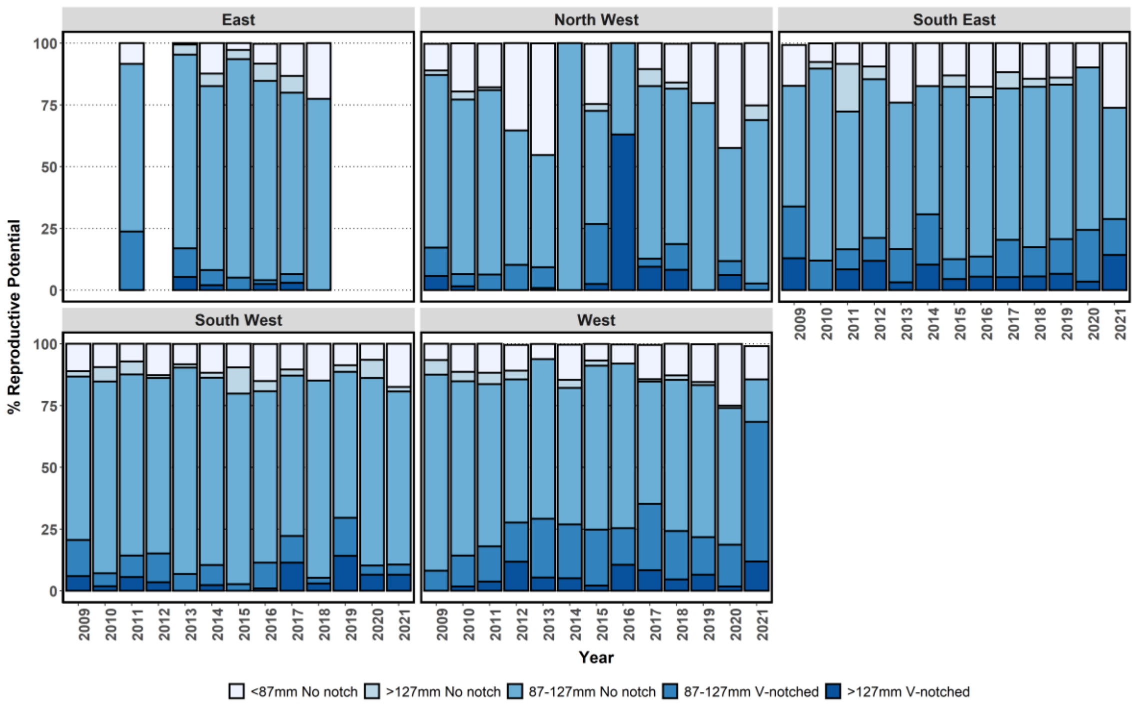

Figure 4. Summary of the distribution of the % reproductive potential in lobster stocks conserved by v- notching, minimum size and maximum size measures by region. Marine Institute Observer data 2010-2021.

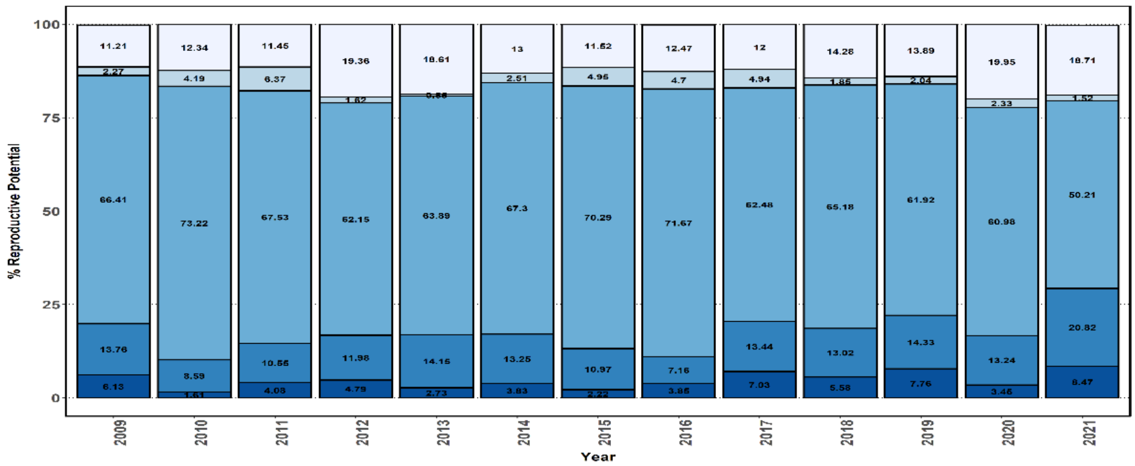

Figure 5. Summary of the distribution of the % reproductive potential in lobster stocks conserved by v- notching, minimum size and maximum size measures for all regions combined. Source: Marine Institute Observer data 2010-2021.

4.7 Catch rates

4.7.1 Seasonal and annual trends

This report includes the SVP data from 2013-2020 and the MI observer data from 2014-2021. Before 2014, observer trips were very limited and thus, catch rate data is not shown. SVP data and data from various earlier voluntary logbook programmes prior to 2013 are being compiled.

In the SVP, lobsters are generally reported in either numbers or kilograms. Numbers are reported in this analysis. Weights were transformed to numbers based on the modal size for V-notched lobsters

(106 mm) from observer data. A length-weight relationship from port-processor data was applied (**W**=1.42*10-^{6}**L**$^{2.84}$) where W is weight and L is carapace length.

The catch rates of legal (LPUE) lobsters and underside (DPUE) lobsters from 2013-2020, all areas combined, were stable (Figure 6, Figure 7). Observer data generally reports higher catch rates, especially for the discarded component. The SVP discard rate (DPUE) was lower in 2020. Seasonally, LPUE generally peaks in quarter 3 and declines in quarter 4. This is probably a combined effect of in season landings and reduced catchability, related to declining temperatures, later in the year.

4.7.2 Size composition

The annual size composition data of discarded and landed lobsters is stable (Figure 8). The number of lobsters measured in the observer programme however has declined in recent years.

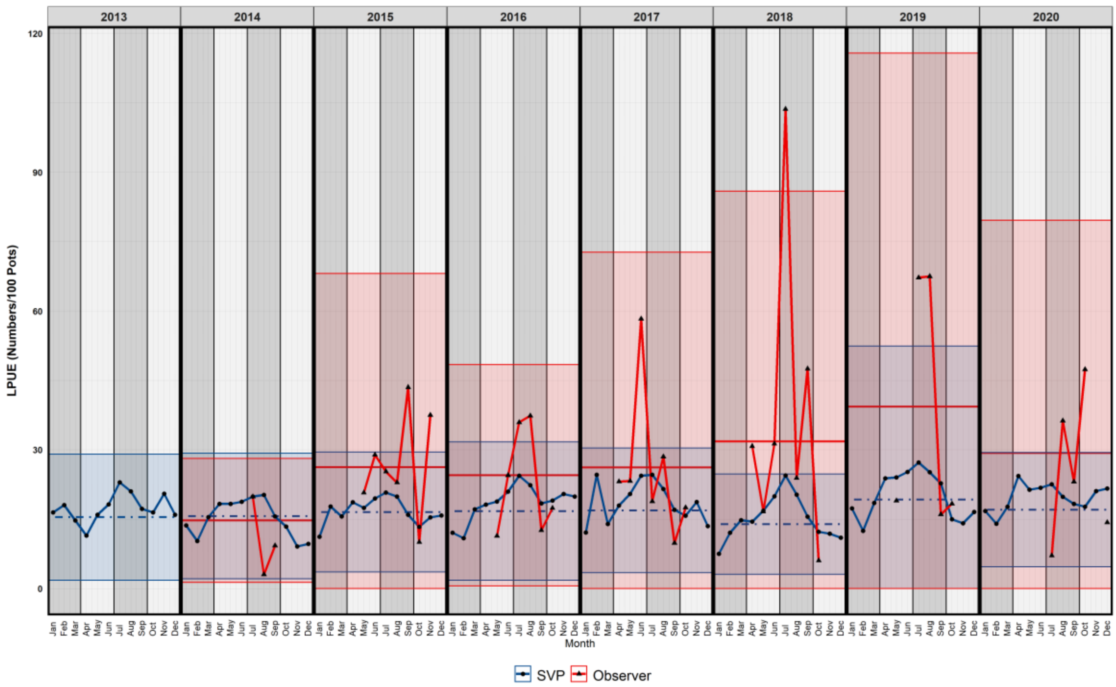

Figure 6. Annual mean landings of lobster per effort (100 Pots) for the SVP (2013-2020) and MI Observer programme (2014-2020).

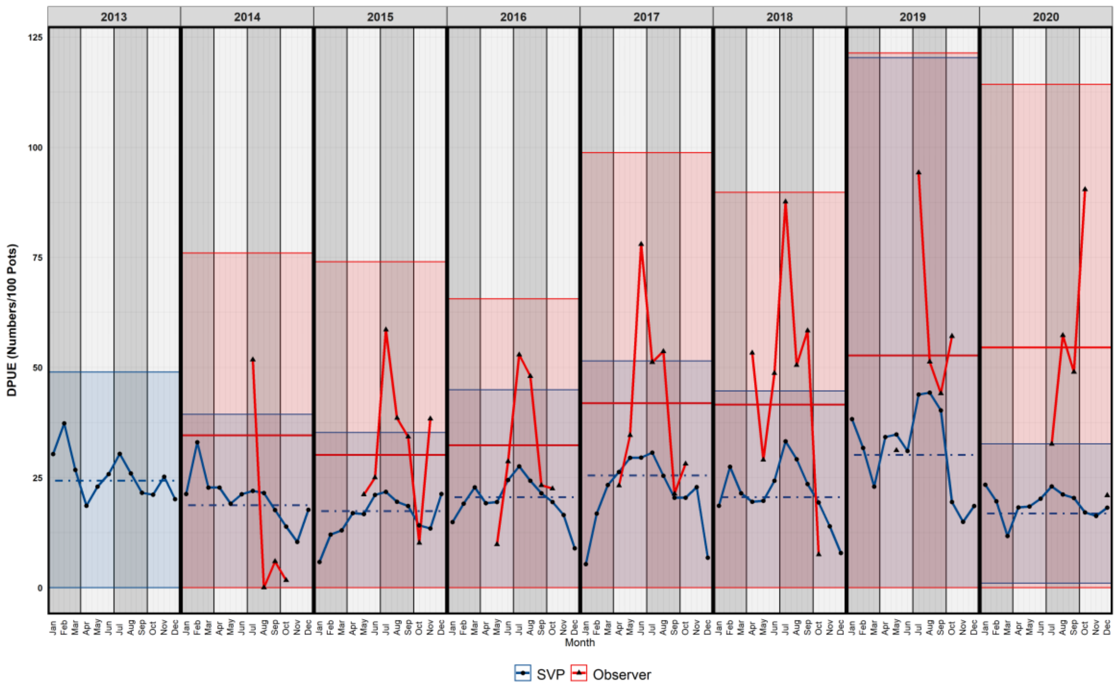

Figure 7. Annual mean landings of lobster per effort (100 Pots) for the SVP (2013-2020) and MI Observer programme (2014-2020).

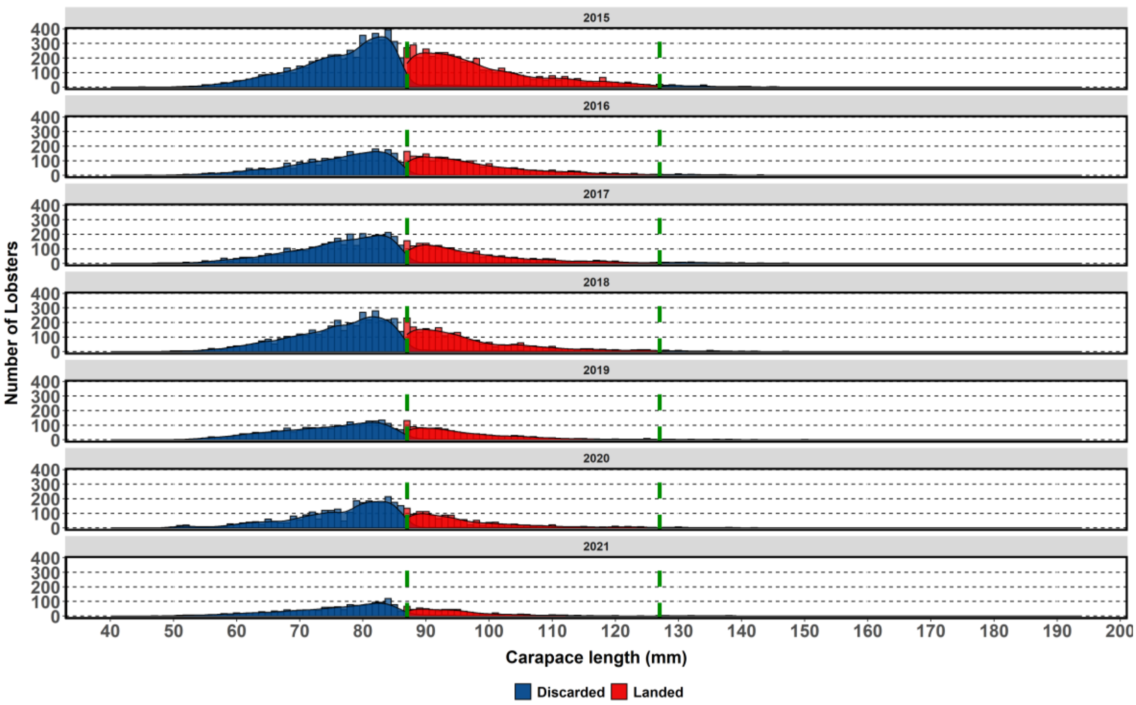

Figure 8. Annual size distributions of discarded (<87 mm, >127 mm) and landed lobsters across all regions. Marine Institute observer data 2015-2021.

5 Crayfish (*Palinurus elephas*)

5.1 Management advice

Crayfish are managed using a minimum landing size (MLS) of 110 mm. There are two areas, one off west Galway and a second in Tralee Bay, closed to netting. V-notched crayfish cannot be landed. This measure was introduced to protect tagged crayfish and currently has limited conservation value as there is no v-notching scheme as such.

Catches of crayfish vary from 5-25 individuals per nautical mile of net hauled. This varies seasonally and geographically. Unit value is very high at between €35-50 per kg. About 50 % of the catch is under the MLS but this varies by year. Mortality of crayfish caught in nets can reach 50% at certain times of year.

A number of endangered and protected species are caught as by-catch in large mesh tangle nets used to target crayfish. The fishery off the south west coast in particular overlaps with an area of high diversity of elasmobranch fish and is close to grey seal haul outs and areas designated for harbour porpoise. Spider crab, brown crab, crayfish and lobster are the most common commercial species in the catch. Twelve species of elasmobranch fish (skates and rays) occur in the by-catch. Of these white skate, angel shark, flapper skate and blue (common) skate are critically endangered. There is a high by-catch of grey seal relative to the size of the main seal population at the Blasket Islands.

Critically endangered species cannot sustain by-catch mortality caused by the tangle net fishery. Measures should be introduced to eliminate the by-catch of critically endangered species and to significantly reduce the by-catch of protected species. Alternative fishing practices to reduce mortality of crayfish in the catch need to be considered.

5.2 Issues relevant to the assessment of the crayfish fishery

Crayfish have, since the mid-1970s, been fished primarily with large mesh (25 cm) entangling nets. Prior to this top entrance pots were the main gear used in the fishery. Fisheries data, other than landings, have not been routinely collected. Data on catch per unit effort could provide indices of biomass but these data and size distribution data are sparse, of variable quality and were not collected systematically prior to 2017. Sampling effects and crayfish movement in and out of sampling areas probably confound these data and their use in estimating fishing mortality rates.

New data on species catch composition in the tangle net fishery, catch rates and size distributions have been obtained recently (2017-2021) off the south west coast and is ongoing. Tag recovery data suggests that mark-recapture methods may be used to estimate the stock size.

5.3 Management units

The life cycle of crayfish suggests that there is a single stock in north west Europe where high levels of connectivity may be maintained by larval dispersal. The larvae phase lasts for between 6-9 months and larvae produced off the Irish coast may disperse into oceanic waters to the west of Ireland. Larval behaviour however and their possible association with small species of jellyfish may reduce the dispersal scale. The dynamics of larval supply back to coastal reef habitats have not been established and it is also possible that there is a link between larval production and recruitment at smaller spatial scales.

Although crayfish tagged off Brittany have recently been recorded off the west of Ireland crayfish tagged off the south west coast of Ireland have also been recaptured locally and repeatedly in different years and there are no reported captures over wider areas. Acoustic tagging data for crayfish in the Mediterranean indicates homing to release location. There are no significant stocks of crayfish north of Ireland. The fishery closest to Ireland is at the Scilly Isles and Brittany. Until connectivity, relevant to management, across these areas is shown Irish stocks should be managed separately.

5.4 Management measures

The minimum landings size in Ireland is 110 mm (compared to 95 mm in EU regulations). Many areas in Britain and elsewhere also use an MLS higher than 95 mm. Netting is prohibited in Tralee Bay and in an area off west Galway. It is prohibited to land v-notched crayfish. This measure currently has little conservation effect given that there is no v-notching scheme for crayfish. The measure was introduced to protect crayfish that are tagged and enabled multiple mark recapture data to be collected.

5.5 Catch composition

Spider crab are, numerically, the most common species caught in tangle nets off the Kerry coast followed by brown crab and crayfish. Significant numbers of lobsters are caught. Commercial fish caught in tangle nets include turbot, monkfish, pollack and spurdog and thornback rays along with low numbers of spotted and blonde rays. Other non-commercial species are caught including protected species such as grey seal and critically endangered species such as angel shark, flapper skate, blue or common skate and white skate (Table 5).

Table 5. Species catch composition in tangle nets targeting crayfish off the south west coast of Ireland 2017-2021. Data are total numbers caught in each year by all boats in the sampling programme. The geographic areas sampled in 2021 was broader and involve more vessels.

Species	2017	2018	2019	2020	2021	Total
Spider Crab (*Maja brachydactyla*)	3,294	7,320	7,369	3,931	6,439	**28,353**
Brown Crab (*Cancer pagurus*)	3,548	7,034	3,783	3,360	5,243	**22,968**
Crayfish (*Palinurus elephas*)	3,817	4,147	3,328	3,893	7,357	**22,542**
Lobster (*Homarus gammarus*)	500	785	658	757	511	**3,211**
Pollack (*Pollachius pollachius*)	11	185	203	65	351	**815**
Monkfish (*Lophius spp*)	38	89	79	72	227	**505**
Turbot (*Scophthalmus maximus*)	37	58	87	133	82	**397**
Spurdog (*Squalus acanthias*)	49	155	1,115	583	1,852	**3,754**
Thornback (*Raja clavata*)	52	88	165	117	273	**695**
Dog fish (*Scyliorhinus spp*)	37	6	1	10	558	**612**
Spotted Ray (*Raja montagui*)	0	11	22	59	196	**288**
Grey Seal (*Halichoerus grypus*)	8	45	73	74	55	**255**
Unidentified Skate	70	26	1	5	0	**102**
Blonde Ray (*Raja brachyura*)	0	26	5	0	71	**102**
Common Skate (*Dispturus batis*)	0	3	0	0	83	**86**
Painted Ray (*Raja microocellata*)	0	6	0	4	54	**64**
Flapper Skate (*Dipturus intermedius*)	0	5	8	0	34	**47**
Sting Ray (*Dasyatis pastinaca*)	0	1	0	2	23	**26**
Undulate Ray (*Raja undulata*)	0	1	0	0	**3**	**4**
Angel Shark (*Squatina squatina*)	0	0	2	1	0	**3**
Cuckoo Ray (*Leucoraja naevus*)	0	0	2	0	**0**	**2**
White Skate	0	1	0	0	**0**	**1**
Total	**11,636**	**19,992**	**16,901**	**13,066**	**24,706**	**86,301**

5.6 Catch rates

Catch rates of crayfish generally varied from 5-25 fish per nautical mile of net during 2017-2021. This includes all sizes (Figure 9). Catch rates are higher around the Blasket Islands and in the south of the area compared to outer Tralee Bay (Figure 10). The size distribution data shows variable proportions of the catch are above the minimum size in each year; 34 % in 2017 and 53-62 % in 2018-2021 (Figure 11). This variability in the size composition suggests that there is significant movement of crayfish into or out of the area although this is not borne out by the tagging data which suggests a high level of residency and repeated re-captures of individual crayfish close to release sites.

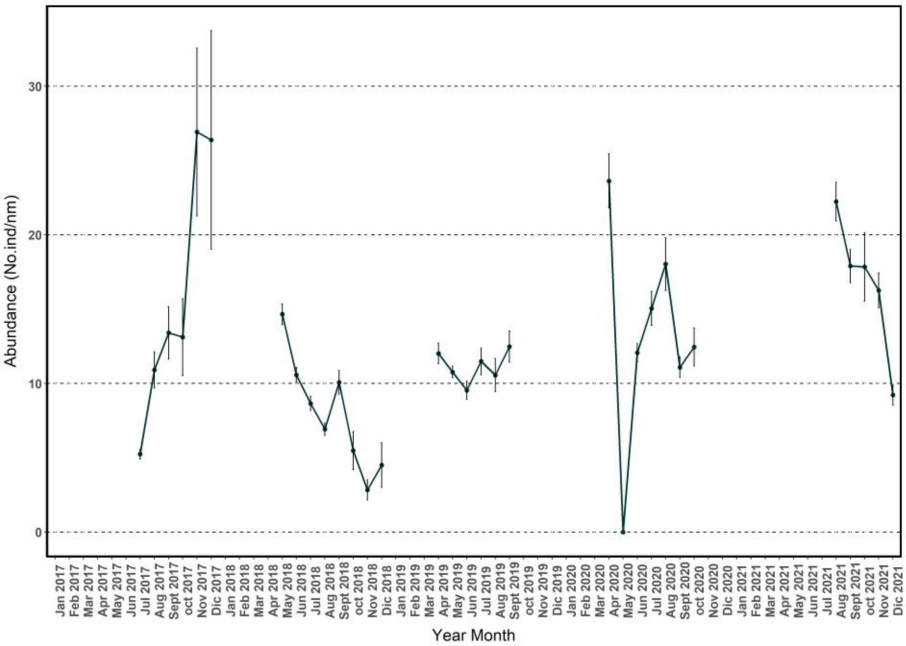

Figure 9. Catch rate (numbers.nmnet^{-1}) of crayfish off the south west coast of Ireland 2017-2021.

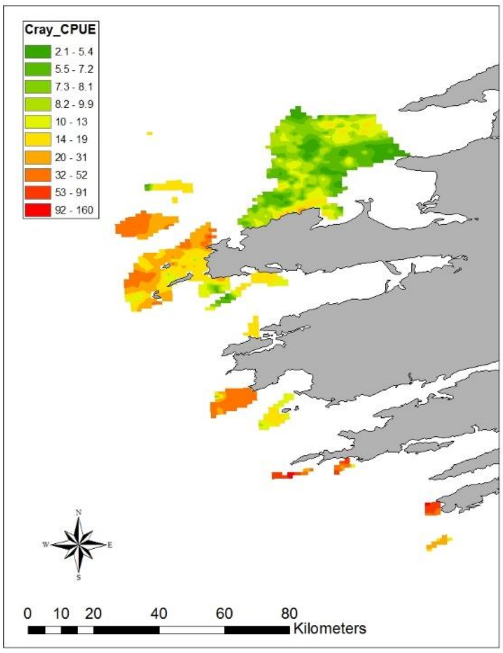

Figure 10. Distribution of catch rate (numbers.nmnet^{-1}) of crayfish 2017-2021 combined.

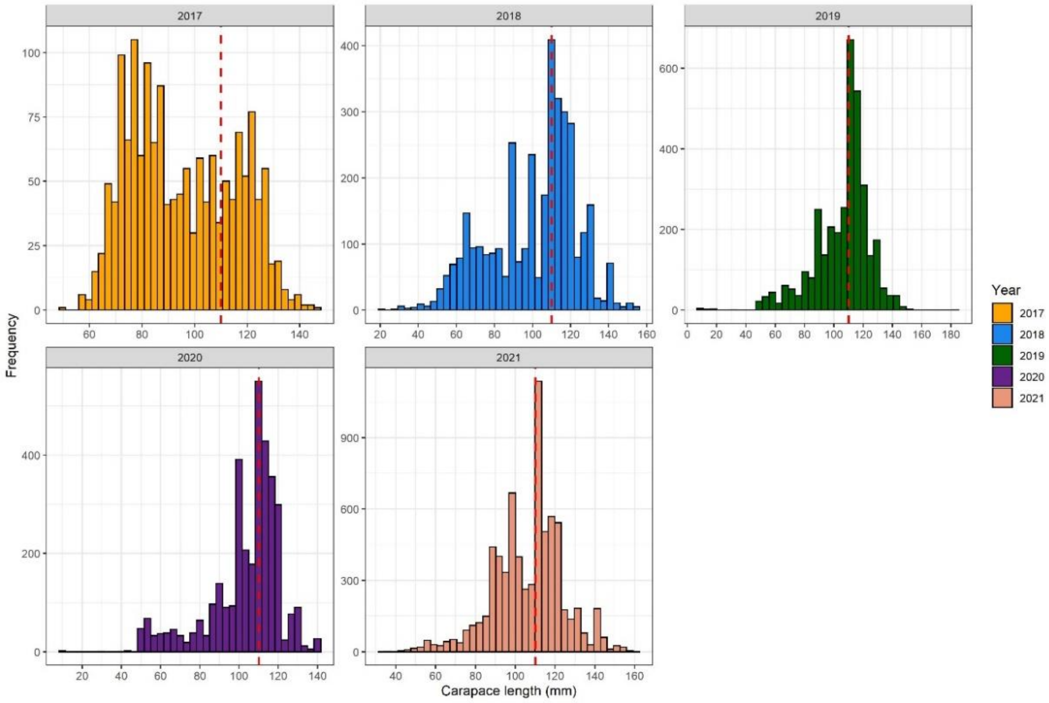

Figure 11. Size distribution of crayfish in the catch off the southwest coast or Ireland 2017-2021.

6 Brown crab (*Cancer pagurus*)

6.1 Management advice

The crab fishery is managed by a minimum landing size of 140 mm. There are kilowatt day (kw.day) limits on vessels over 10 m in the biologically sensitive area which includes coasts from north Mayo south and east to Waterford and on vessels over 15 m in ICES area VI.

The crab fishery is monitored using data from commercial vessels and a scientific observer programme. In addition, size distribution data of the landings is collected at processors.

Standardised index of stock abundance and a stock assessment, based on a production model, show a steep year on year decline in both landings per unit effort, discards per unit effort, increasing fishing mortality and declining biomass since 2014/2015 in the Malin Shelf fishery. The production model assessment incorporates landings by Scottish and Northern Irish vessels. These trends are also generally observed in other crab stocks off the Irish coast.

Advice based on the negative trends in stock indices or on the F/F_{msy} ratio, in the case of the Malin stock, all indicate the need to reduce fishing mortality. Corresponding landings for the Malin Shelf would reduce from 6,650 to 2,512 tonnes (all fleets combined). Landings for the south west coast would reduce from 1,235 to 690 tonnes and landings for the Celtic Sea would reduce from 1,076 to 834 tonnes.

Although the MLS of 140 mm significantly protects the stock from recruitment overfishing the data clearly signals a decline in stock abundance and a likely decline in recruitment in recent years given that trends in discard rates (of smaller crab) are also negative.

6.2 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. Capacity to account for spatial and temporal effects in an annual standardised index depends on the spatial resolution of the data in particular.

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. 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, seasonal and other effects on catch performance.

6.3 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 and south to Galway, 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 tagging data, distribution of fishing activity and larval distribution.

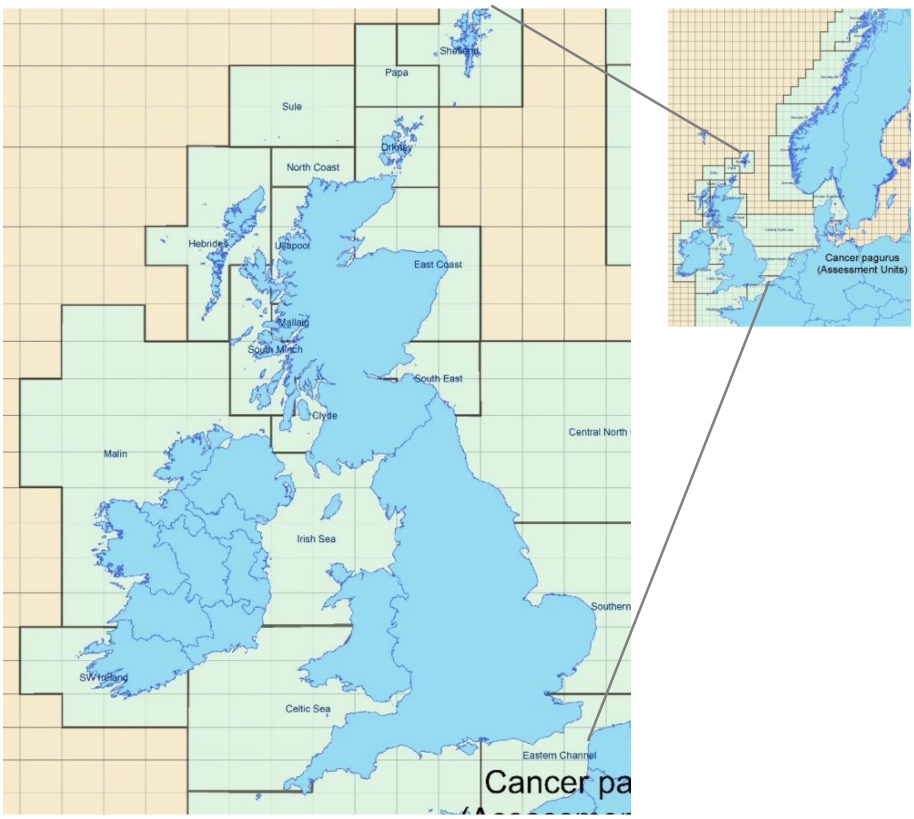

Figure 12. ICES stock assessment units for Brown crab.

6.4 Management measures

Crab are managed using a minimum landing size of 140 mm. Annual effort by vessels over 15 m in length is restricted (1415/2004 EC) to 465,000 kw.days in ICES Area VI (north west stock), to 40,960 kw.days in ICES Area VII outside of the Biologically Sensitive Area (BSA) and to 63,198 kw.days in the BSA for all vessels over 10 m in length. These restrictions have resulted in some displacement of effort of offshore vessels (>18 m in length) from the Malin Shelf to the North Sea and on occasion the restrictions may limit fishing activity towards the end of the year by vessels over 10 m. Effort by vessels under 10 m in length is unrestricted in all areas.

6.5 Catch rates

Sentinel vessel (SVP) data from 2013-2020 and the MI observer data from 2015-2020 for all coasts are presented here. Data prior to 2014 is presented for the Malin Shelf stock only as data for other areas is still being compiled.

Landings and discards of brown crab in the SVP are reported in different units, i.e. kilograms, boxes, trays and numbers. The data for this review is reported in kilograms. A box of landings/discards was assumed to be approximately 30 Kg based on previous reports from observer trips. One tray was assumed to represent half a box.

6.5.1 Annual trends

Landings per unit effort (LPUE) was stable during 2013-2015 in SVP vessels targeting crab with an annual mean of approximately 2.5 Kg/Pot. This declined between 2015 and 2019 from approximately 2.3 Kg/Pot in 2015 to approximately 1.1 Kg/Pot in 2019 and 1.2 Kg/Pot in 2020. The MI observer data declined from 2.2 Kg/Pot in 2016 to 0.2 Kg/Pot in 2020 (Figure 13). This decreasing trend in LPUE was observed in all stocks up to end of 2019 (Figure 14). Targeted LPUE was higher in the Celtic Sea in 2020 than in the previous 3 years. This recovery occurred in targeted crab fishing for both legal and undersized crabs. Discards per unit effort (DPUE) show similar trends in both SVP and MI observer data, with a marked decrease from 2015 onwards, and reaching values of 0.2 Kg/Pot in 2020. LPUE and DPUE of crab caught in gear targeting lobster were relatively stable but generally less than 0.5 Kg/Pot. The MI observer data is probably more reflective of mixed targeting of lobster and crab compared to the SVP where the data shows distinctly higher crab catches in pots intended for crab.

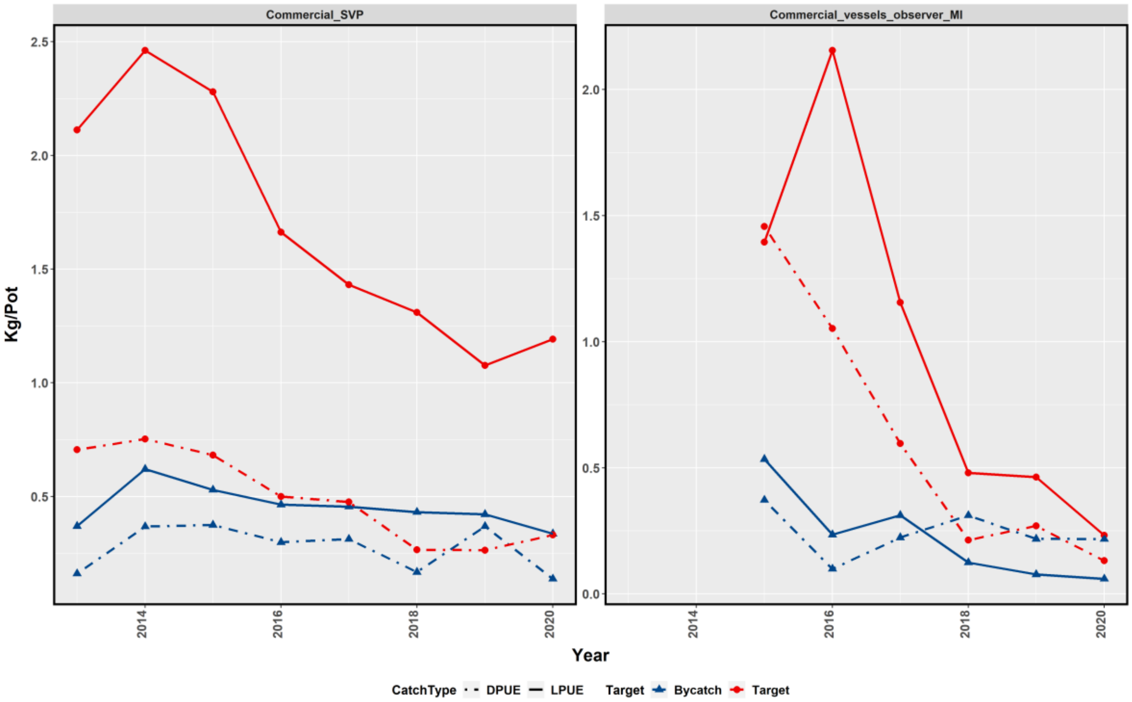

Figure 13. Annual mean LPUE and DPUE (Kg/pot) for Observer and SVP programme data from trips both targeting brown crab and where brown crab is caught as by-catch 2013-2020. All stocks combined.

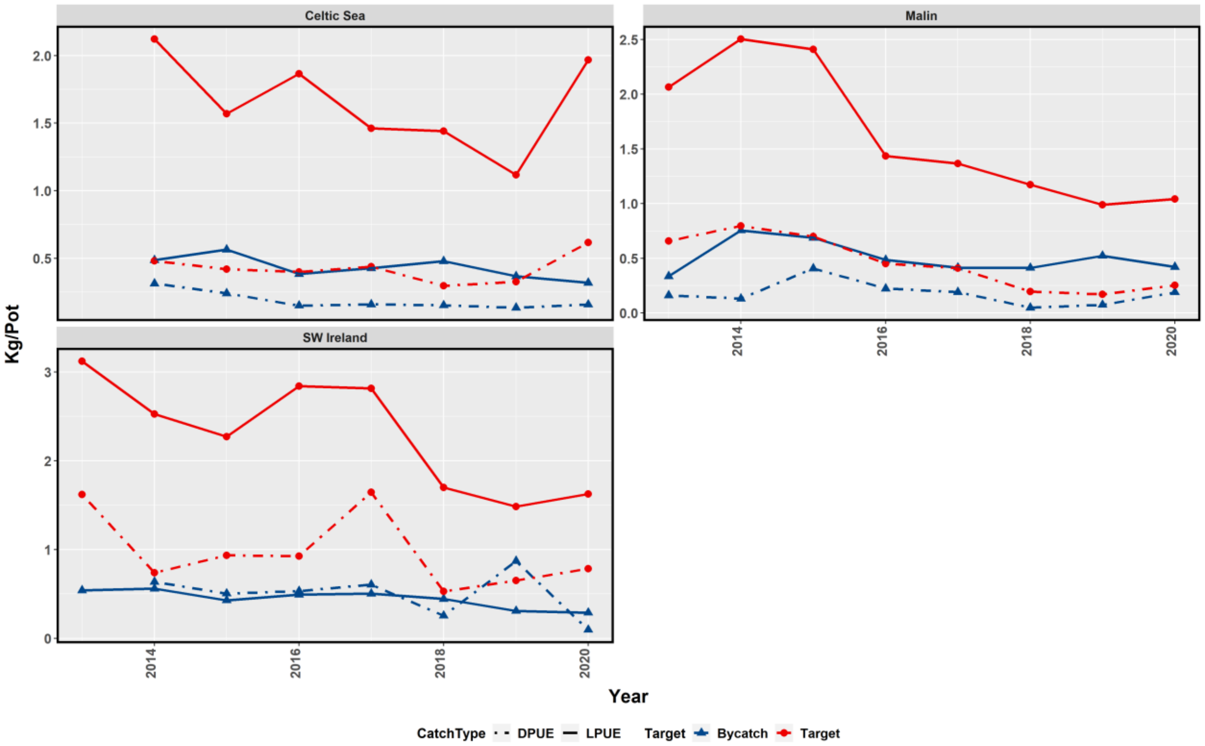

Figure 14. Annual mean LPUE and DPUE (Kg/Pot) by stock area for SVP trips targeting crab and also where crab is caught as bycatch during 2013-2020.

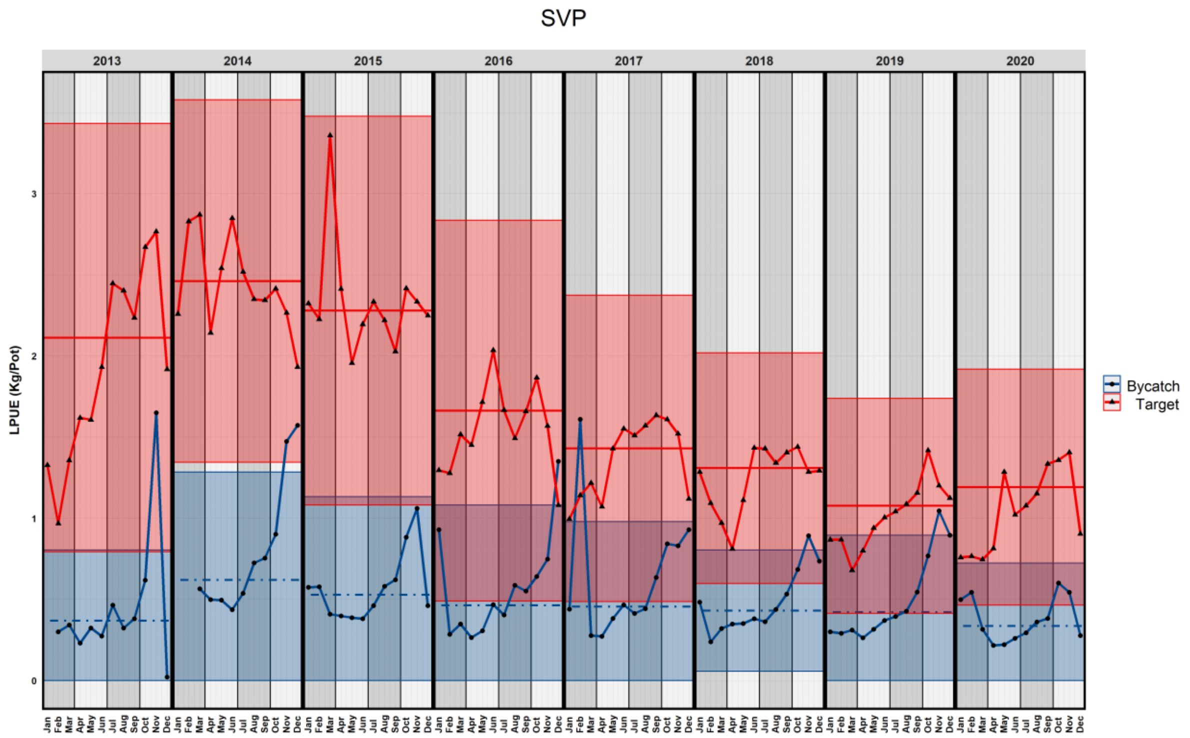

Figure 15. Monthly mean LPUE (Kg/pot) with standard deviation for SVP trips where crab was targeted (blue) and captured as bycatch (brown). Horizontal line in each year show annual means. Year quarters shaded in grey and white.

6.5.2 Seasonal trends

Seasonal trends in LPUE in the SVP data are shown in Figure 15. Observer data is not shown as it is considerably less precise given the limited sampling. LPUE in gears targeting crab generally show peaks in Quarter 3 and early Quarter 4 although in 2013-2016 peaks occurred in Quarter 1 and 2. LPUE of brown crab caught in pots targeting lobster generally peaks in Quarter 4.

6.6 The Malin Stock

6.6.1 Landings

The northwest crab fishery developed during the 1970s on a small scale and further development occurred during the 1980s in inshore waters especially off Malin Head. In 1990 the offshore vivier fleet was introduced and there was incremental modernisation of the inshore fleet. Throughout the time series, from 1980 to 2020, Irish vessels landed the largest proportion of Brown crab from the Malin stock. Landings peaked in 2004 at almost 8,000 tonnes. The peak in Irish landings observed in this year did not occur in the Scottish or Northern Irish data. Scottish landings remained relatively stable from the early 90's, whereas Northern Irish landings show a continuous increase with the exception of 2019 when landings fell (Figure 16).

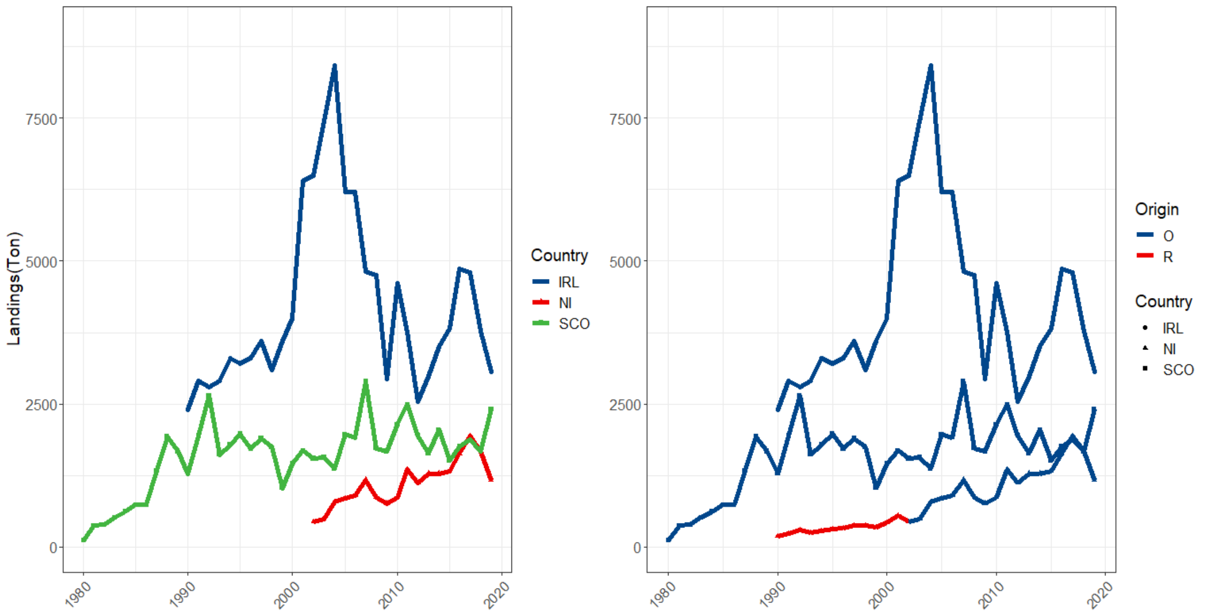

Figure 16. Landings (tonnes) of brown crab (*Cancer pagurus*) in ICES Divisions VIa and VIIb (Malin Shelf stock) 1990-2019 by Irish (IRL), Northern Irish (NI) and Scottish (SCO) vessels. Source: Logbooks data for vessels above 10 m and sales notes data for vessel under 10 m. Data for Northern Ireland are reconstructed from 1990-2011 based on a general linear modelling framework (red line: R).

6.6.2 Biomass indices

Two potential indices of abundance are available for the stock

1- Daily landings per unit effort (LPUE) collected in the SVP or earlier versions of it from 1996-2020 and
2- Georeferenced haul by haul LPUE (Figure 17), from the Irish Offshore crab fleet from 1991-2006.

Additional information available in both datasets include soak times and unique vessel identifiers. Data on discards was available in the SVP programme but are not always reported and are not included here.

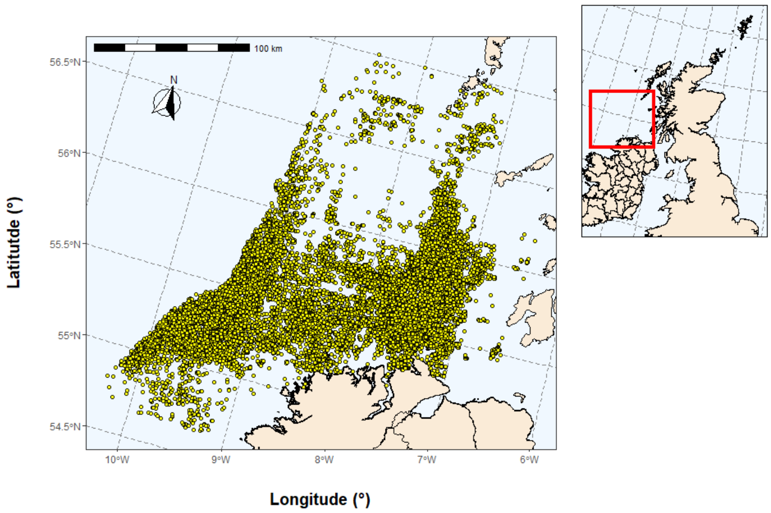

Figure 17. Haul locations for the offshore vivier crab fleet 1990-2006.

Commercial catch rate data can be used as a true index of abundance if the effects on catch rates of factors (co-variates) other than changes in crab abundance can be accounted for. This process is usually referred as catch rate standardization. In the case of the SVP programme, only trips targeting crab were used in the standardization analysis to reduce the variance in the LPUE estimates that would result if vessels targeting lobsters with a crab by-catch were included. When the target species intention was not recorded for a particular vessel or trip, it was assumed that vessels above 8 m total length tend to target brown crab. An extensive data exploration was carried out before any model implementation to identify potential issues, such as outliers (in both landings or effort) or missing data.

For both datasets, two independent gamma distributed Generalised Additive Model's (GAM) were developed with the following base form:

$$\eta_i = log(\mu_i) = \beta_o + offset\big(log(Noofpots)\big) + \beta_Y Year + s(SoakDays_i \sim \text{"}cs\text{"}) + s(Vessel_i \sim \text{"}iid\text{"})$$

$$Landings_i \sim Gamma(\mu_i, \phi)$$

$$var[Landings_i] = \mu_i^2/\phi$$

$$\phi = exp(\theta)$$

where mean μ_i is the expected landings (kg of crab) on trip i and is linked (log link) to the linear predictor η_i, φ is the precision parameter from the gamma distribution and βY is the coefficient for the explanatory variables (Y= year), fitted as fixed effects. The term s() defines smoothing effects, as cubic spline ("cs") for SoakDays, to account for potential non-linear relationships between catch and soak time, and a single random effect ("iid") for Vessel ID, to account for potential correlation of observations from the same vessels. The "offset()" is used to incorporate the fishing effort (Number of pots) into the model based on a 1:1 relationship between catch and effort. This accounts for changes in catch rates that might be related to overall effort rather than changes in crab abundance. The offshore vivier index standardization, besides the terms described above, also accounted for potential gear saturation, defined as the effect on LPUE of the number of pots set 3 days before a specific fishing event and within a 5 km buffer zone, as well as an additional random effect to account for spatial and temporal correlation among observations at haul level.

In both models, the resulting index of abundance was based on the predictions of the fitted model for standard values of the covariates, and for every location in the case of the spatiotemporal model. The vessel effect was removed from the predictions.

The SVP index show a relative increase in LPUE in the first 10 years of the time series (Figure 18). A sharp decrease in the standardized LPUE occurred from 2014 onwards. GAM_fixed (a fixed categorical year effect), shows substantially more inter-annual variability compared to GAM smooth; the splines in the second model smooths differences across years. In GAM_fixed, 2008 appears as a clear outlier in the standardized index. The limited sampling in this year for the Malin stock (4 vessels only compared to on average 13-15 vessels) are likely to be causing this outlying estimate.

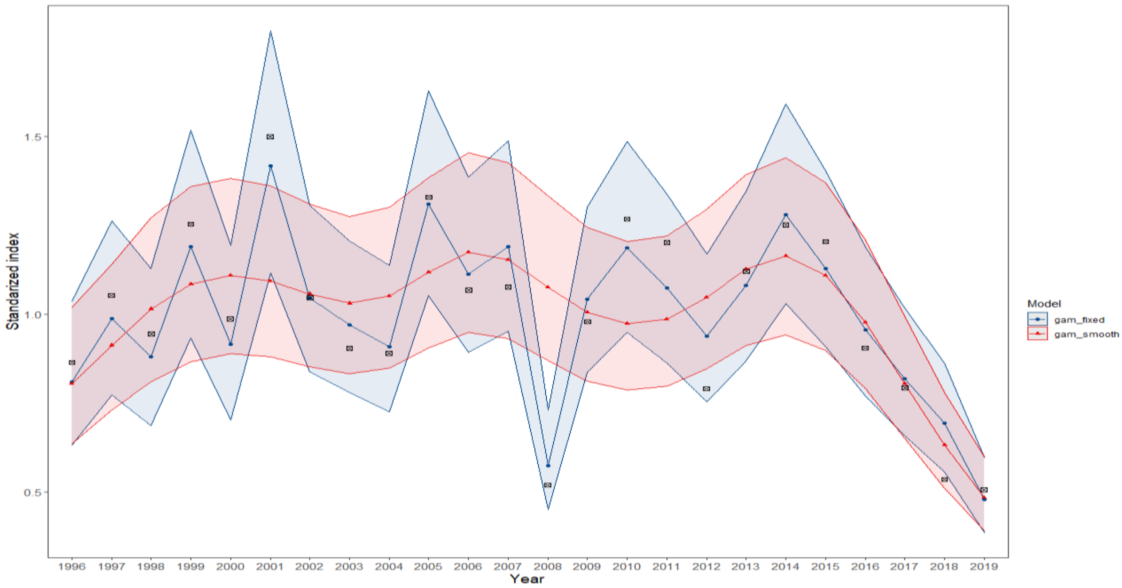

Figure 18. Standardized index of crab abundance from the SVP programme after applying two different GAM model formulations (Gam_fixed: Year as fixed effect, Gam_smooth: year as spline). Shaded regions indicate approximate 95% confidence intervals. Annual mean raw LPUE (black squares) added for comparison.

The offshore vivier standardized index shows a declining trend at the beginning of the time series and stable LPUE between 1994 and 2000 followed by small declines from 2000-2006. This trend was similar across different spatial-temporal model formulations (Figure 19).

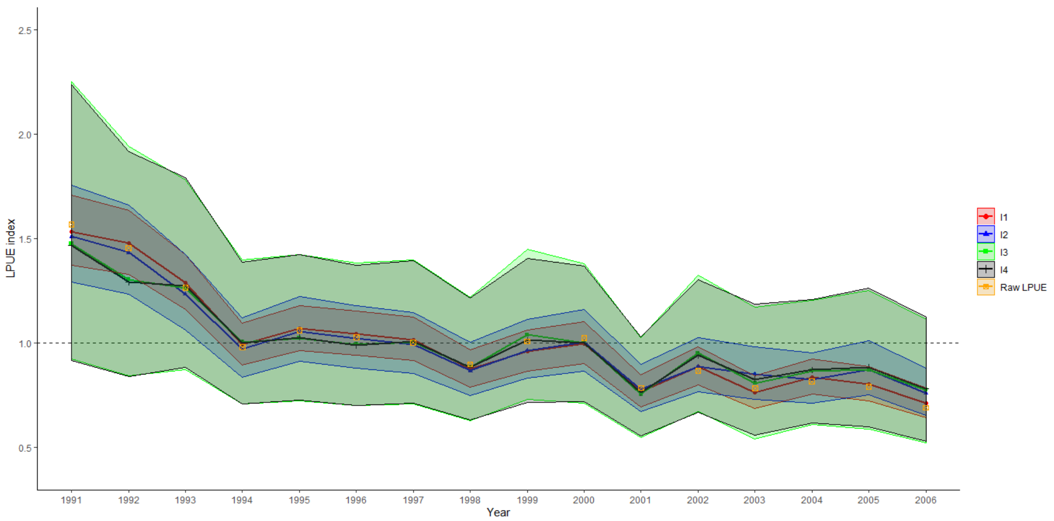

Figure 19. Standardized offshore LPUE time series using four different spatial-temporal model formulations in INLA. Nominal LPUE as squares included for comparison.

6.6.2.1 SPiCT assessment

SPiCT (surplus production in continuous time) is a version of a surplus production model which are commonly used in fisheries assessments. The model enables error in the catch process to be reflected in the uncertainty of estimated model parameters and management quantities. Estimates of exploitable biomass and fishing mortality can be obtained at any point in time from data sampled at arbitrary intervals. A number of model scenarios were tested which included varying the time series of landings and catch rate indices included in the assessment and the initial settings for key model parameters (symmetry of the production curve, depletion at the beginning of the time series and intrinsic growth rate for crab).

SPiCT outputs indicate that the stock entered an overfished state around 2016 (Figure 20). Fishing mortality (F) is currently much higher than optimum fishing mortality rates (F_{msy}) and stock biomass (B) is well below the biomass that, on average, would optimize stock productivity (B_{msy}).

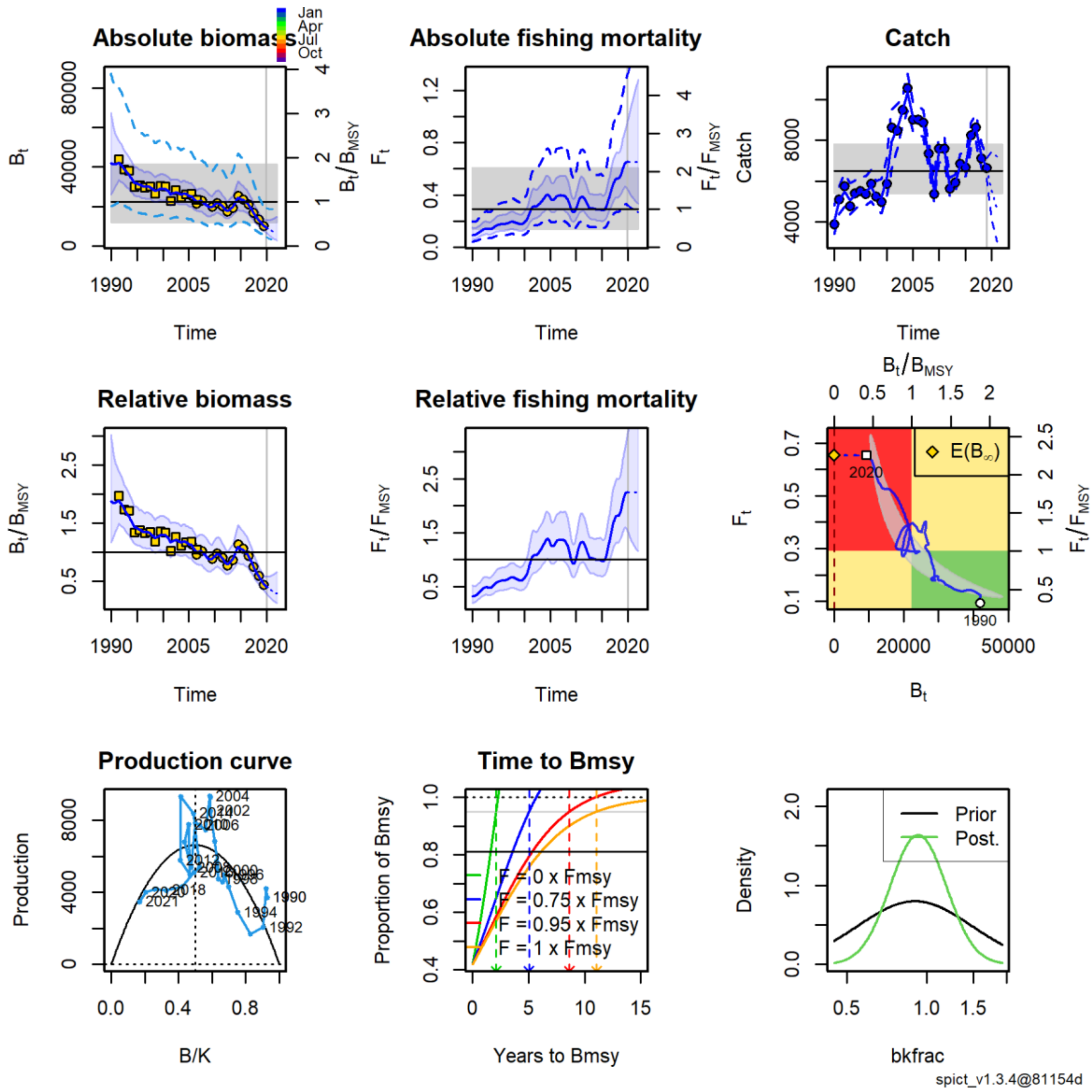

Figure 20. SPiCT outputs showing the evolution of fishing mortality (F) and biomass (B) relative to reference points F_{msy} and B_{msy}.

6.6.3 Catch advice

The assessment shows that fishing mortality should be reduced in all stocks. The level to which fishing mortality is reduced depends on the harvest control rule that is adopted. Two rules are considered below;

1. Fish at F_{msy}
2. Apply the so called 2/3 rule as applied to ICES category 3 stocks for which only trends, rather than a full stock assessment, are available.

The F_{msy} advice is taken directly from the assessment model presented above. The F_{msy} rule reduces the F/F_{msy} ratio (and corresponding landings) back to 1 or the fishing mortality rate that may lead to recovery of the stock to B_{msy} levels. The 2/3 rule takes the average index value (LPUE) in the 2 most recent years in the assessment and for which full data are available (2018, 2019), divides it by the average index value in the 3 years prior to that (2015-2017) and applies it to the most recent year for which landings are available (2020). As the index is declining this rule advises a reduction in landings.

The 2/3 rule and the F_{msy} rule provide similar catch advice for the Malin Shelf stock.

Table 6. Current landings and advised landings based on Fmsy and implementation of the 2/3 rule.

Stock	Current landings	Landings at Fmsy	Landings 2/3 rule
Malin Shelf	6,650	2,512	2,420
South west	1,235	-	690
Celtic Sea	1,076	-	834

Implementation of the harvest rules to reduce fishing mortality provides scope for stock recovery but does not guarantee recovery. Other sources of mortality may also have increased in recent years. These are unknown and cannot be managed.

6.6.4 Interpretation

The year on year decline in the observed and standardised LPUE index between 2014 and 2020 has not been previously observed in the time series which extends back to 1990. Although the LPUE indices can be confounded by changes in grading practice, unrelated to the minimum landing size, it is unlikely to be the cause of the decline in recent years. Observed discard rates (DPUE) also declined from 2016-2019 in parallel with the LPUE index. Decline in LPUE could be linked to growth overfishing whereby the removal of crabs above the MLS occurs at a higher rate than they can be replaced by growth but corresponding declines in DPUE and LPUE signal an overall year on year reduction in the abundance of crab in the fished area. Crabs in the discards are not all recent recruits to the stock and include a number of age classes. The decline in discards, therefore, may signal a reduction in recruitment in the past number of years.

The minimum size of 130 mm and more recently 140 mm has been regarded as sufficient to protect the stock from recruitment overfishing given that the size at maturity is approximately 120 mm. Spawning escapement is, therefore, significant and above 30 % of what it would be in an unfished stock. A number of spawning events occur before crabs are exposed to fishing mortality. High grading at observed modal size of about 150 mm provides further protection. Fishing is unlikely to be the sole cause of the recent declines in stock abundance. However, recruitment decline combined with high fishing effort will further reduce spawning stock biomass. In such a case, fishing mortality (landings) should be reduced to avoid further depletion in stock biomass.

7 Razor clam (*Ensis siliqua*)

7.1 Management advice

All commercially exploited razor clam stocks in Ireland 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. Smaller scale fisheries on the west coast have operated successfully under voluntary management plans in recent years.

Landings in the North Irish Sea declined between 2015-2021. 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 up to 2017 but were stable from 2017-2020. Estimates of biomass, revised following a review of data standardisation protocols in 2020, varied from approximately 9,000 tonnes in 2017 to between 6,000-7,000 tonnes in 2018-2020 and 9,145 in 2021. Exploitation rate was 7.5 % per annum. Large size classes were depleted between 2017 and 2018 but were stable or increased between 2018-2021. Based on average landings 2019-2021 or applying the average exploitation rate for the period 2019-2021 of 7.5% to the average survey estimates for the same period landings in 2022 should not exceed 563 tonnes.

The south Irish Sea fishery opened in 2010 and expanded up to 2013. A strong recruitment event in Rosslare Bay in 2014 (probably) was observed in the 2017 survey and biomass increased significantly between the 2017 and 2020 from 2,000 to 6,300 tonnes. The estimate for 2021 was 5,300 tonnes. A further 1,500 tonnes was estimated in the Curracloe bed in 2021. On the basis that a 7.5 % exploitation rate has led to stable biomass, size distribution and commercial catch rates in the North Irish Sea landings for 2022 in the south Irish Sea should not exceed 535 tonnes.

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 some bivalve fauna caught as by-catch is depleted in Dundalk Bay. Spatial management measures in Dundalk Bay should be introduced to enable recovery of these species and to monitor changes in marine communities following removal of fishing pressure.

7.2 Issues relevant to the assessment of the razor clam fishery

Razor clams (*Ensis siliqua*) occur along the east coast of Ireland in mixed 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 well sorted sands on the west coast. Both species may occur in the same area. The distribution of commercial stocks and fisheries is currently known from high frequency VMS data for the commercial fishery which operates in water depths of 4-14 m. Surveys of small areas along the west coast in 2016 provide further information on distribution of these species. Many of these areas are not currently fished. 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 occur 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 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 is considered in the assessment advice.

7.3 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 south 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, west and north west coasts. Fisheries occur or have previously occurred in Clifden Bay, Iniskea Islands, Ballinakill Bay, Killary Harbour and Inisbofin county Mayo, Rutland sound Co. Donegal and the Waterford estuary.

7.4 Management measures

New management measures were introduced for the Rosslare – Curracloe 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 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).

7.5 North Irish Sea

The North Irish Sea (NIS) fishery began in the early 1980s and quickly developed 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 in the fishery by 1999. Post 2003 beds at Malahide, Skerries and south Dundalk Bay were being fished in addition to the Gormanstown bed. The number of vessels in the fishery, total fishing effort and annual landings expanded significantly between 2014 and 2018. The fishery has supported over 70 vessels in recent years and landings peaked at over 1,100 tonnes and a value of approx. €6.5m in 2015. The catch is exported mainly to the Far East. Unit prices vary by grade or shell size from €4-10 per kg. The fishery, relative to other shellfish, could be classed as 'medium price and medium volume'.

The fishery occurs close to the coast in shallow sub-tidal waters along the east coast from Dundalk south to Malahide.

7.5.1 Landings

Landings increased from 274 tonnes in 2012 to over 1,100 tonnes in 2015. This was paralleled by an increase in the number of vessels to 54 in 2015. The number of vessels peaked in 2016-2018 to between 71 and 78 but landings declined to 600-700 tonnes in 2016-2019. The number of vessels declined to 56 in 2019. Landings were about 500 tonnes in 2020 but fishing effort was low (42 active vessels) due to Covid 19 restrictions and poor market conditions. There was a small increase in landings in 2021 to about 550 tonnes. The Dundalk Bay and Gormanstown production areas account for most of the landings (Figure 21).

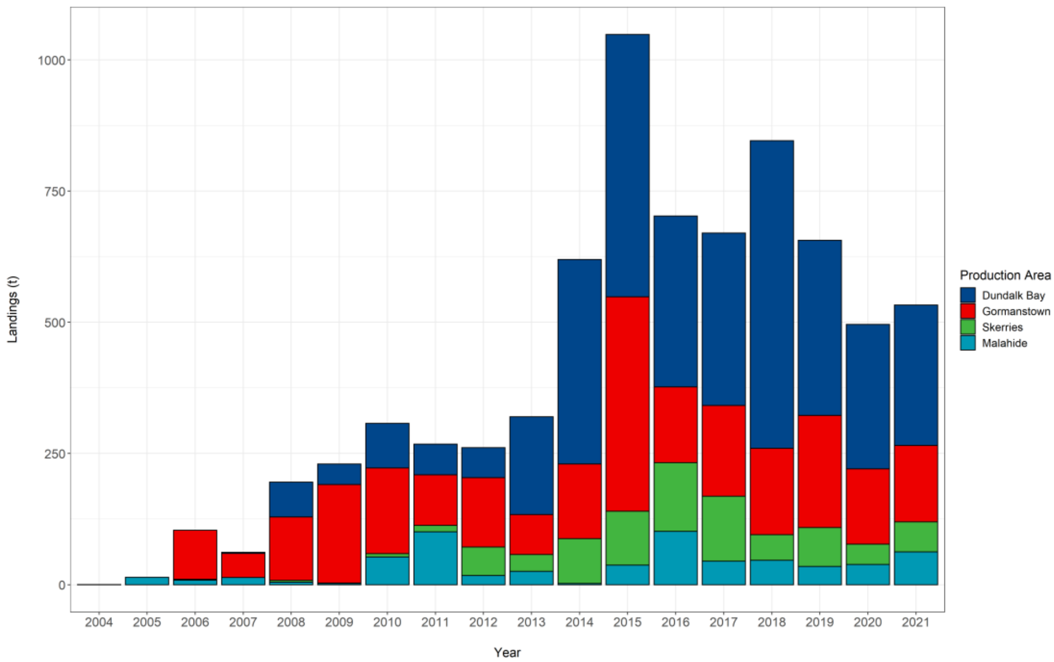

Figure 21. Annual landings of *Ensis siliqua* in the north Irish Sea (NIS) 2013-2021 sourced from SFPA logbook, and sales notes data. Figures reported have been updated according to latest sales note data.

7.5.2 Survey 2021

A survey encompassing all of the areas which are commercially fished for Razor clams was completed in the north Irish Sea in June 2021. The survey follows the same design to that used in 2017-2020 where survey effort was allocated from an iVMS grid; 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 were defined, and 50 stations were randomly assigned within each stratum, to ensure an even distribution of randomly assigned grid cells across the range of iVMS effort. The survey was mostly completed over a 4-5 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. 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.

A standardised protocol was established and applied to the NIS survey data from 2017-2021 in order to avoid potential differences in biomass estimates from year to year due to the change in the total surveyed area, the geostatistical assessments modelling routines and to control for various issues surrounding the acquisition of accurate GPS data during surveys. In this report these protocols have been applied retrospectively and biomass estimates may therefore be different to those reported in previous years

7.5.2.1 Biomass 2017-2021

Biomass varied from approximately 9,300 tonnes in 2017 (kriging estimate) to between 5,400-6,900 tonnes in 2018-2020 and 9,145 tonnes in 2021 (Figure 22). Over 80 % of the biomass was above the minimum landing size of 130 mm and 65% was above 150 mm.

Higher biomass (kgs.m^{-2}) occurred in south Dundalk Bay, south Gormanstown and at Malahide in the south of the survey area (Figure 23). Nevertheless, densities were low in Dundalk and catches were predominantly of large clams compared to Malahide where densities were high and catches were dominated by small size clams.

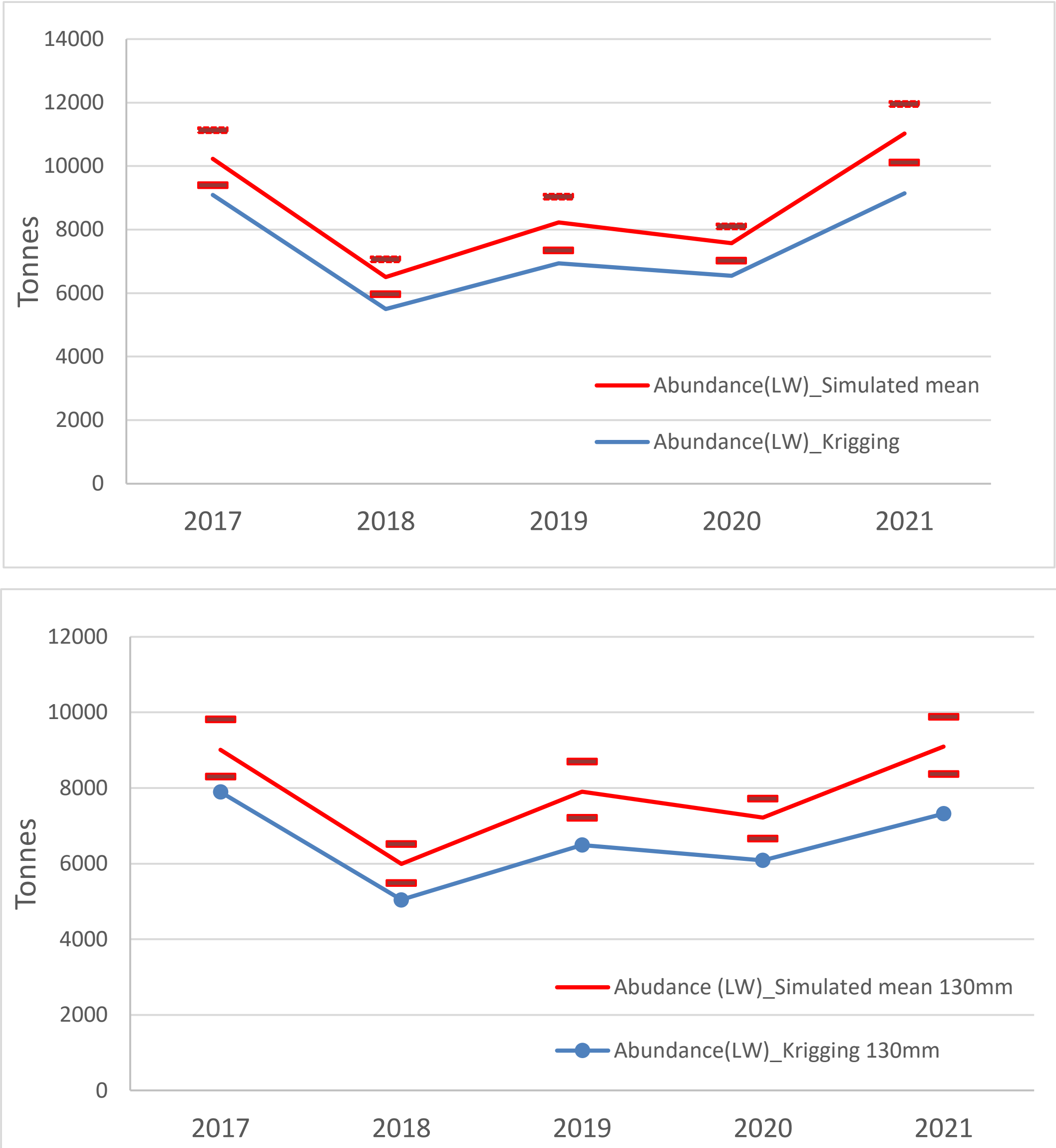

Figure 22: Trends in stock biomass of razor clams 2017-2020 in the north Irish Sea. Top: total biomass. Bottom: biomass greater than shell length 130 mm.

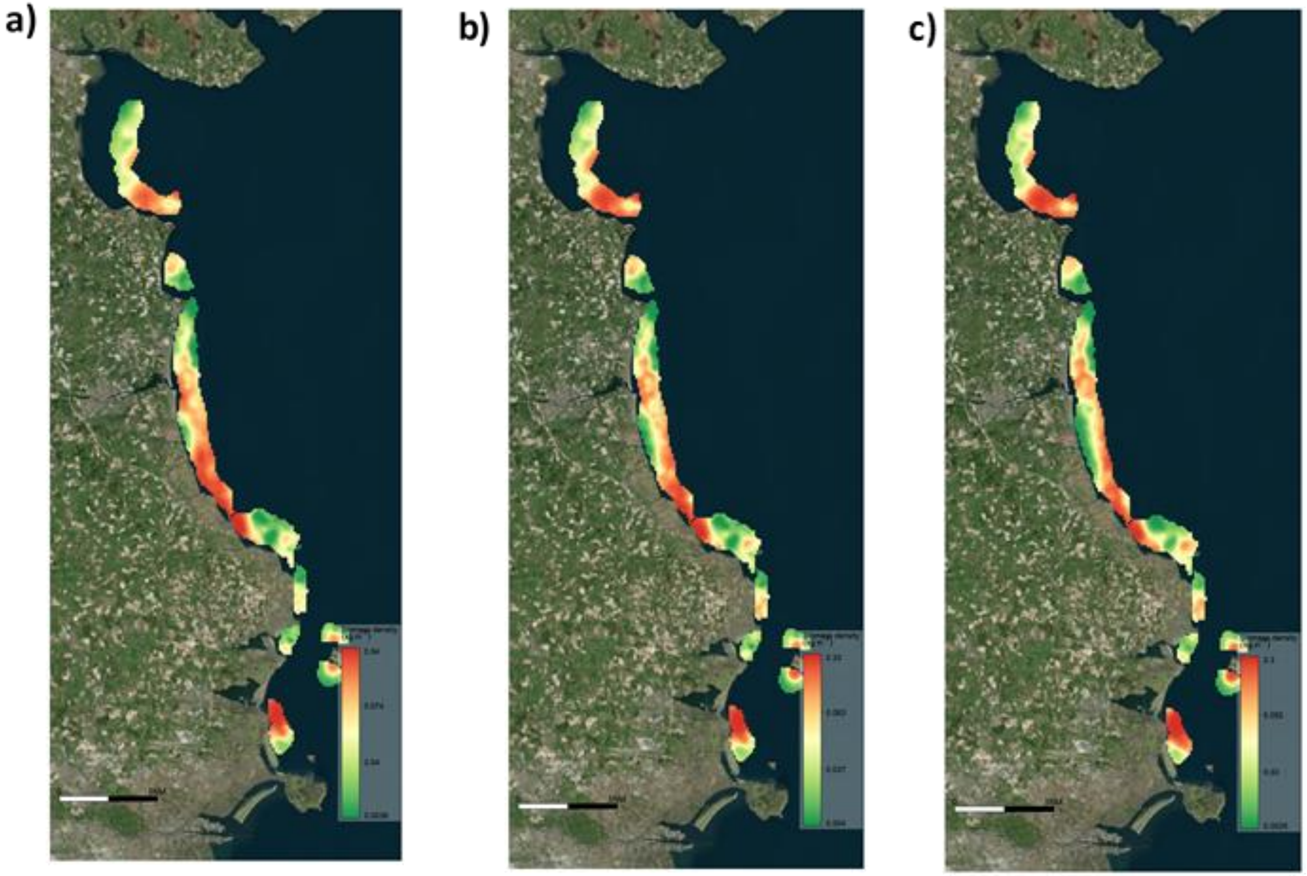

Figure 23. Distribution of biomass of razor clams in the north Irish Sea in June 2021. a) all sizes, b)>130mm, c)>150mm.

7.5.2.2 Size distribution

The modal size class above the MLS of 130 mm was approximately 160 mm in 2020 and 2021. Size classes below the MLS, weakly detected in the 2020 survey were strongly represented in 2021 at a mode of approximately 120 mm (Figure 24).

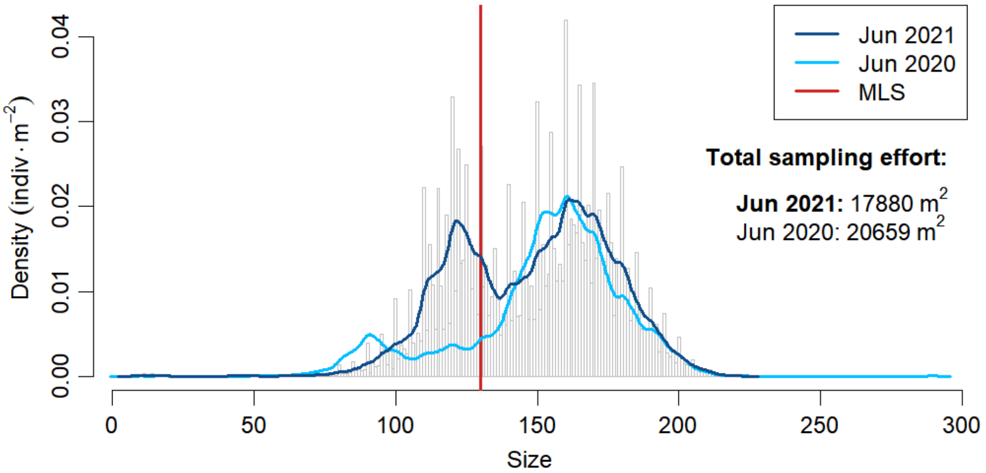

Figure 24. Size distribution of razor clams in the North Irish Sea from 2020-2021 survey data.

7.5.3 Commercial Catch rates (LPUE)

Catch rates estimated from SVP data show a declining trend from 2013 to 2017. Catch rate was stable at about 12-13kgs per hour in 2017-2019 and increased to 19kg.hr in 2020 (Figure 25).

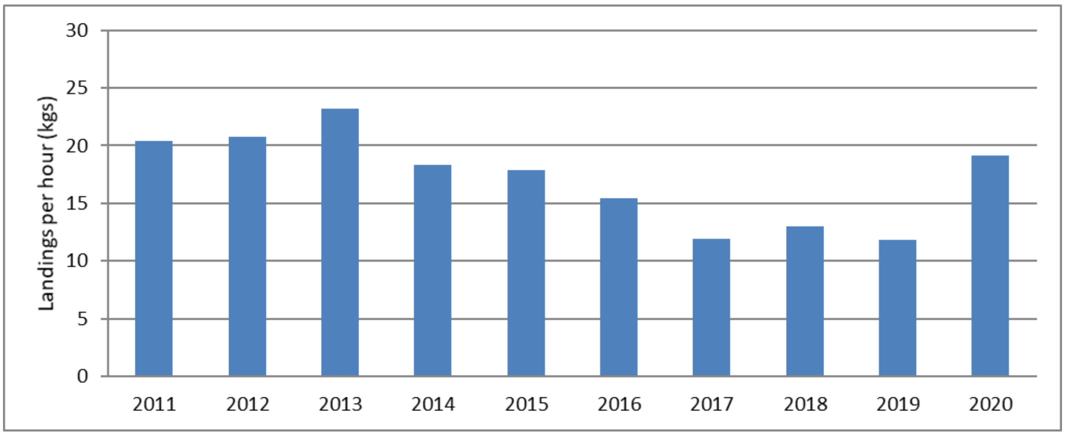

Figure 25. Annual average landings per unit effort in the north Irish Sea razor clam fishery 2011-2020. Source: SVP data.

7.5.4 Catch advice

Average catch and % of biomass landed in the period 2019-2021 was 553 tonnes and 7.5 %, respectively. Surveys indicated that biomass was relatively stable during that period with an increase in 2021 and there was some evidence of increase in modal shell size and grade structure between 2018-2021. LPUE varied from 184-203 kgs per day from 2018-2020 (SVP data) (Table 7).

Based on recent stable or increasing biomass estimates, stable size structure and increasing catch rates in the fishery advice on landing options for 2022 are:

- Based on average landings from 2019-2021 the landings in 2022 should not exceed 553 tonnes
- Based on applying the average exploitation rate of 7.5% during 2019-2021 to the average survey biomass estimates for the same period the landings in 2022 should not exceed 563 tonnes

Table 7. Trends in landings, biomass, % of the biomass fished and landings rate in recent years

Year	Landings	Biomass	% Exploitation	SVP data (kg.day^{-1})
2017	620	9,097	6.82	186
2018	850	5,497	15.46	184
2019	630	6,936	9.08	191
2020	500	6,542	7.64	203
2021	530	9,145	5.80	
2019-2021 average	**553**	**7,541**	**7.51**	**193**

7.5.5 Economic indicators

Indicators of economic viability of fishing are derived from SVP data that includes partial costs; namely fuel. Net value per hour at sea increased from 2011-2015 due to significant price increases for razor clams and also reductions in fuel price even when catch rates were declining.

Value per hour at sea peaked in 2015 and 2016 and then declined due to continued fall in catch rates, increase in hours at sea and increases in fuel price (Table 8). Price increases in 2019 increased profitability relative to 2017 and 2018 and improved catch rates in 2020 further increased profitability and countered the reported increase in fuel prices.

Table 8. Annual trends in fuel costs, hrs at sea, price of clams, LPUE and net (of fuel) value of the catch between 2010 and 2019.

Year	Daily fuel cost	Diesel per L	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
2020	€340	€0.70	16.1	€5.80	19.10	€2,303.00	

7.6 South Irish Sea

7.6.1 Landings

The fishery in the south Irish Sea opened in 2010. Landings increased from 50 tonnes to 100 tonnes in 2011 and 2012 and peaked at over 200 tonnes in 2016. Landings declined from 2016 to 2019 and were about 30 tonnes in 2021 (Figure 26). The recent declines corresponded with a reduction in fishing effort in the Rosslare Bed in particular as biomass of large grade clams had declined in the period up to 2017 and there was voluntary closure (or part closure) in the period 2018-2019 to enable growth of a strong 2014 year class. The Waterford estuary fishery was closed by court order in 2019.

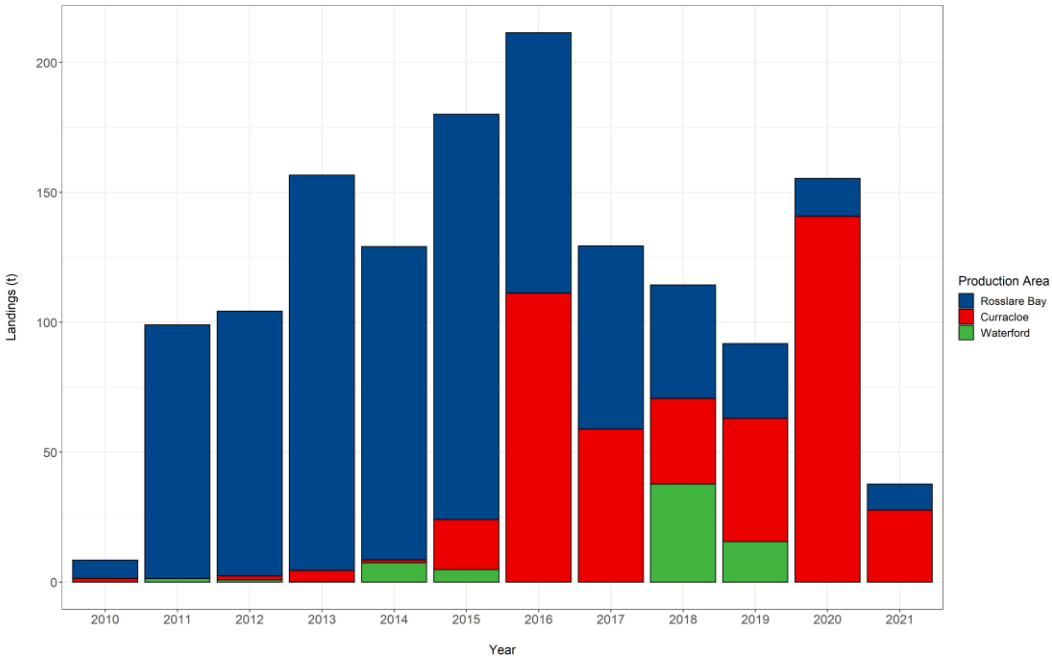

Figure 26. Landings (tonnes) of razor clams in the South Irish Sea by classified production area (CPA). Source: Logbooks/ Sales notes. CPA is assigned by port of landing.

7.6.2 Survey data

Stocks of Razor clams in the South Irish Sea are distributed in two main beds; Rosslare Bay and north along the east coast of Wexford at Curracloe. With the exception of the southern limit of the Curracloe Bed, the distribution of razor clams is well known, and the extent of the beds is included in both surveys.

7.6.2.1 Rosslare Bay

The razor bed of Rosslare was surveyed on September 14th 2021. A total of 45 tows were undertaken, with a single hydraulic dredge of width 1.25 m. The survey encompassed a total area of 12.3 km^2 and a total sampling effort of 1,407 m^2. Biomass of all size classes of razors, assuming a dredge efficiency of 100 %, varied from 0-1.9 $kgs.m^{-2}$. The estimated biomass was 5,299 tonnes, almost all of which (85 %) was above the 130 mm MLS (Table 9, Figure 27).

Higher densities of razor clams <130 mm MLS were found at the centre of the bed (Figure 27b), whereas razors >150 mm were more abundant towards the northern part of the surveyed area (Figure 27c). Modal size was similar in 2020 and 2021 at approximately 140 mm (Figure 28). There was no evidence of recruitment in either year.

Table 9. Estimates of biomass of razor clams in Rosslare Bay in September 2021.

Ensis siliqua	Biomass		95% HDI inf	95% HDI sup
	Mean	Median		
Biomass_*Ensis siliqua*	5,299.7	5,801.5	4,333.6	7,584.2
Biomass_>130mm_*Ensis siliqua*	4,513.5	5,138.4	3,818.2	6,893.5
Biomass_>150mm_*Ensis siliqua*	955.8	1,818.8	854.6	1,469.8

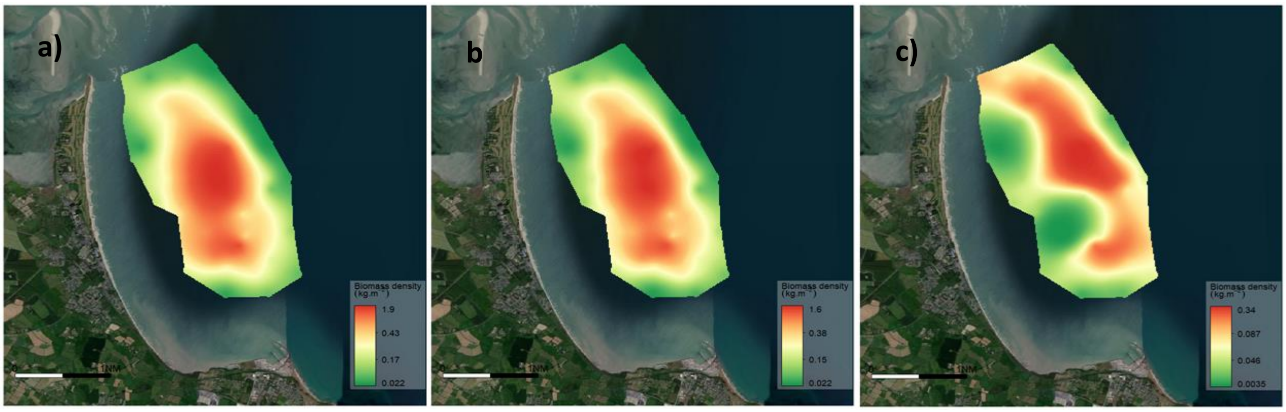

Figure 27. Distribution of *Ensis siliqua* in Rosslare Bay in in 2021, a) all size class, b) >130 mm and c) >150 mm.

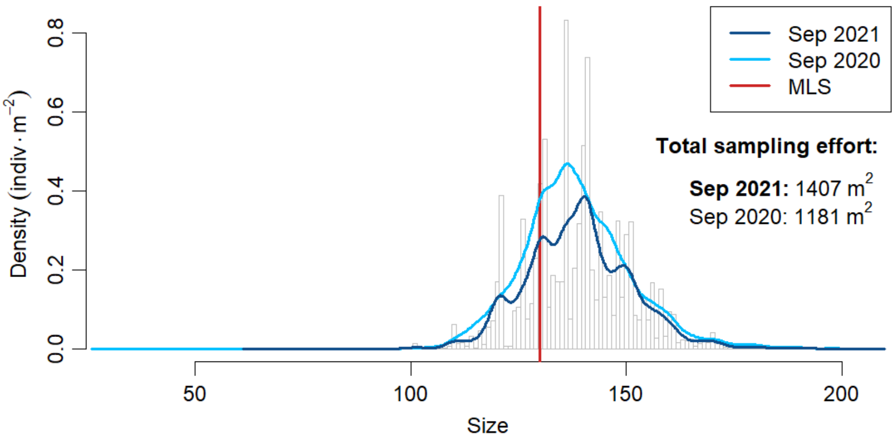

Figure 28. Size distribution of razor clams (*Ensis siliqua*) in the Rosslare Bay 2020 and 2021. Data are standardised to sampling effort regardless of its spatial distribution.

Biomass declined from approximately 6,300 tonnes in 2019 and 2020 to 5,200 tonnes in 2021 (Figure 29).

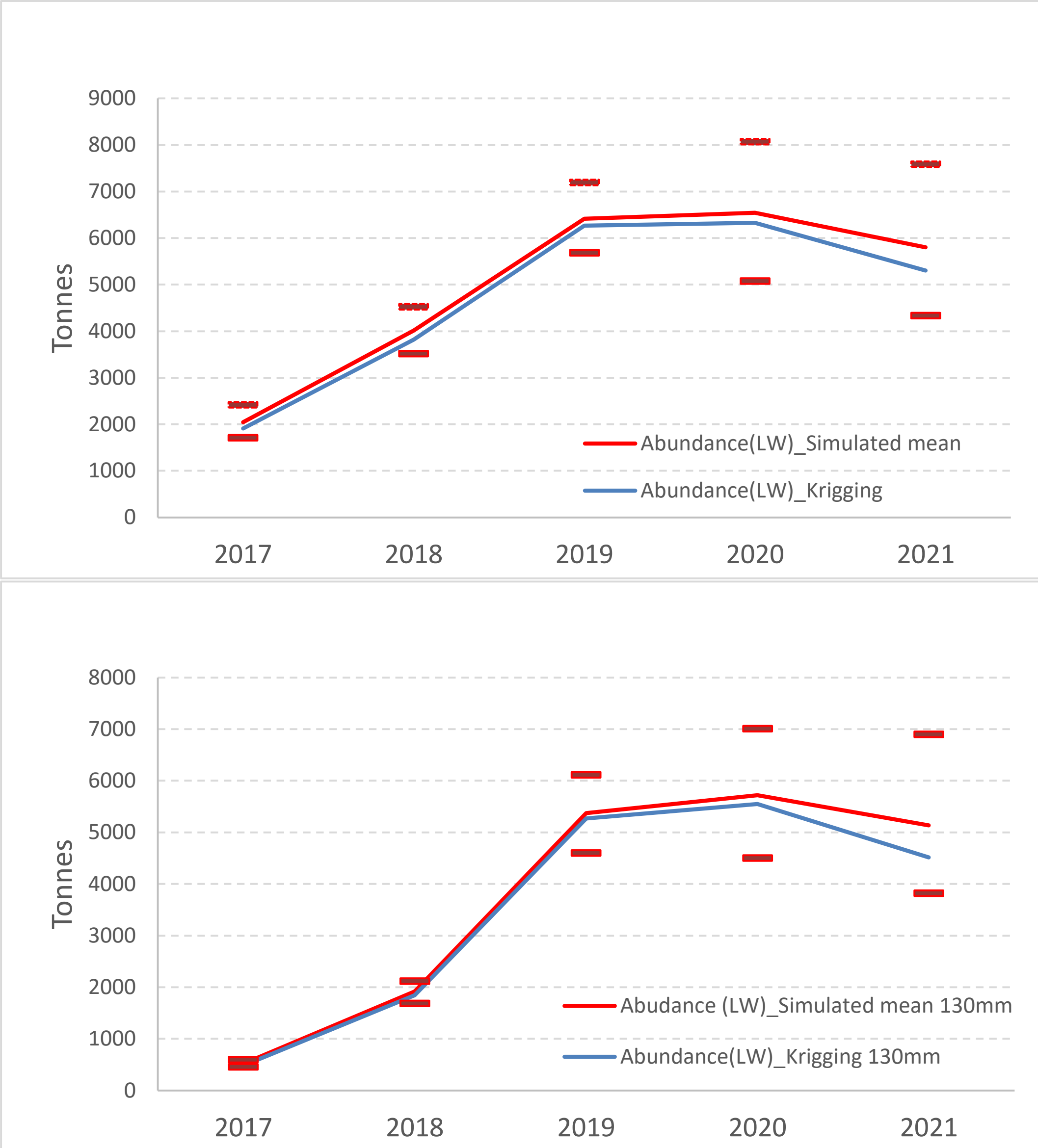

Figure 29. Estimates of biomass of razor clams (*Ensis siliqua*) in Rosslare Bay in 2017-2020 for all size classes (top) and size >130 mm (bottom).

7.6.2.2 Curracloe

The razor bed of Curracloe was surveyed on September 15th and 16th 2021. A total of 62 tows were undertaken, with a single toothless dredge of width 1.25 m. The survey encompassed a combined area of 20.7 km^2 and a total sampling effort of 2,074 m^2.

Biomass of all size classes of razors varied from 0-0.29 $kgs.m^{-2}$ (Figure 30). Distribution of high density patches is similar across size ranges and occurred in the centre and south of the surveyed area (Figure 30). The location of high densities of razor clams towards the southern edge of the survey area suggest that the presence of razor clams may extend further to the south of the production area.

The estimated biomass was 1,486 tonnes, almost all of which (93.2 %) was above the 130 mm MLS (Table 10).

Table 10. Estimates of biomass of razor clams at Curracloe in September 2021.

	Biomass		95% HDI inf	95% HDI sup
	Mean	Median		
Biomass_*Ensis siliqua*	1,468.6	1,626.6	1,346.5	1,959.2
Biomass_>130mm_*Ensis siliqua*	1,385.9	1,544.2	1,259.1	1,858.1
Biomass_>150mm_*Ensis siliqua*	1,057.1	1,227.0	977.7	1,450.0

The modal size of razor clams in Curracloe in 2021 was approximately 160 mm compared to 150 mm in 2020 (Figure 31). The higher densities of razor clams above 150 mm in the 2021 survey may reflect the extended southern limit of the survey compare to the previous year. No recruitment signal is indicated as densities of small razor clams were low.

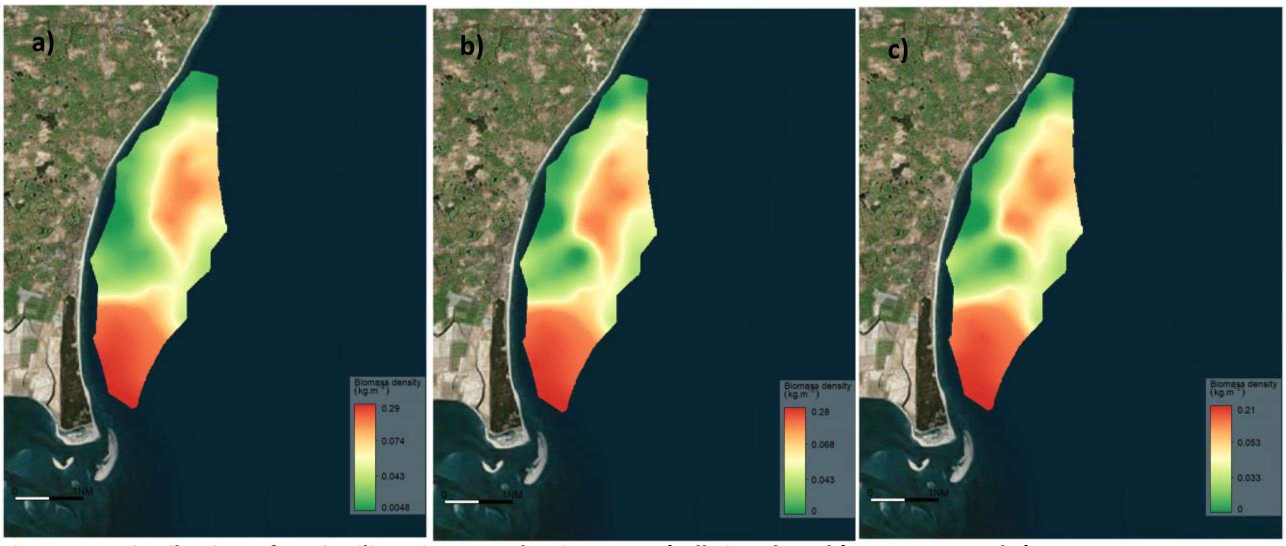

Figure 30. Distribution of *Ensis siliqua* in Curracloe in 2021, a) all size class, b) >130 mm and c) > 150 mm.

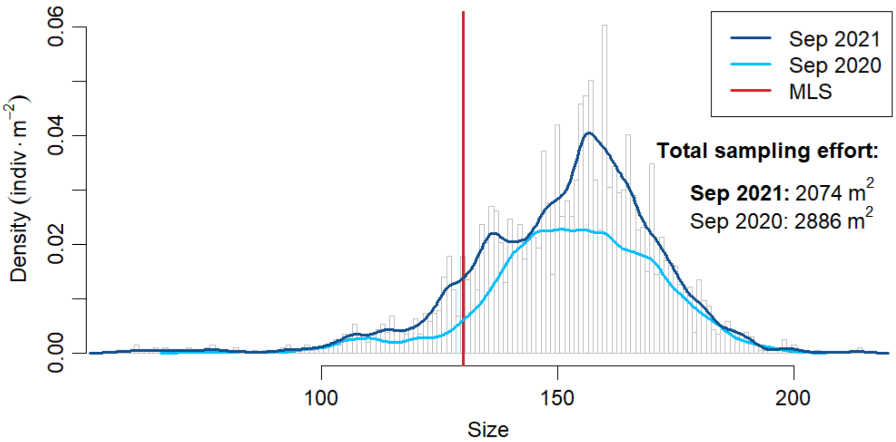

Figure 31. Size distribution of razor clams (*Ensis siliqua*) in Curracloe for 2020 and 2021. Data are standardised to sampling effort regardless of its spatial distribution.

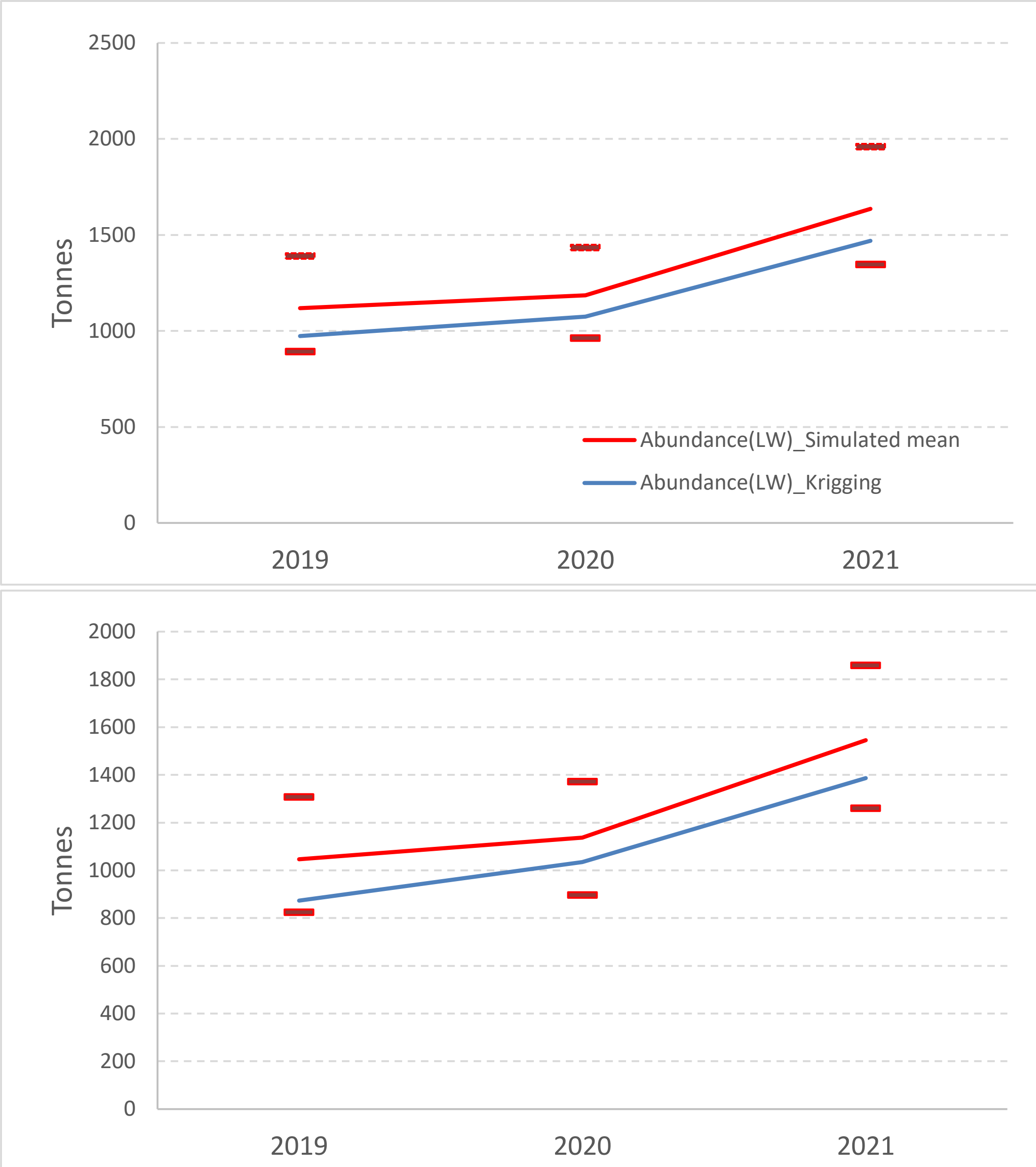

Figure 32. Estimates of biomass of razor clams (*Ensis siliqua*) in Curracloe combined in 2019-2021 for all size classes top) **and >130mm** bottom)**.**

7.6.2.3 Catch advice

Average catch and % of biomass landed in the period 2019-2021 was 87 tonnes and 1.19 %, respectively. Surveys indicated that biomass was stable during that period with an increase in 2021 in Curracloe. Size structure was stable following a progression in modal size from 2020 to 2021 due to growth of a strong recruitment event that may have occurred in 2014 (Figure 31).

Based on recent stable or increasing biomass estimates, stable size structure the landing options for 2022 are:

- Based on average landings from 2019-2021 the landings in 2022 should not exceed 87 tonnes.
- Based on applying the average exploitation rate of 7.5 % for the North Irish Sea to the average survey biomass estimates for the same period the landings in 2022 should not exceed 535 tonnes. The average exploitation rate for the south Irish Sea 2019-2021 was 1.19 %.

However, the substantial increase in biomass from 2017-2020 suggests that higher harvest rates can be supported to exploit the 2014 recruitment event which has now matured to commercial size classes.

- Given recent trends in fishing effort and current market conditions it is unlikely that a 7.5 % exploitation rate will be achieved.

Table 11. Landings, biomass and exploitation rate of razor clams in the south Irish Sea 2017-2021.

Year	Landings	Biomass			% Exploitation
		Rosslare	Curracloe	Total	
2017	130	1,907		1,907	6.82
2018	100	3,818		3,818	2.62
2019	70	6,268	972	7,240	0.97
2020	160	6,330	1,074	7,404	2.16
2021	30	5,299	1,468	6,767	0.44
2019-2021 average	**87**	**5,966**	**1,171**	**7,137**	**1.19**

8 Cockle (*Cerastoderma edule*)

8.1 Management advice

The Dundalk Bay cockle fishery is managed under a Fisheries Natura (management) Plan (FNP) which is a legal mechanism to incorporate environmental protection measures into fisheries management plans when such fisheries occur in Natura 2000 sites.

No fishing occurs at biomass less than 1,200 tonnes. The fishery closes when the TAC (17-33 % of biomass over 1,200 tonnes) is taken or on November 1st or if the average catch per boat per day declines below 250 kg. The minimum landing size is 22 mm shell width. A quota of 1 tonne per vessel per day for 28 permit holders is in force.

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 and the FNP.

Pre-fishery survey estimate of cockle biomass in 2021 was 1,927 tonnes compared to 3,790 and 3,420 tonnes 2019 and 2020 respectively following on from a strong recruitment in 2018. The TAC in 2021 was 642 tonnes of which 638 tonnes were landed.

The harvest control rules in the 2021-2025 FNP should be implemented annually. The FNP will be reviewed in 2025. The estimation of post fishery cockle biomass should be improved.

Maintenance of favourable conservation status of intertidal habitats in which cockle 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 other SACs or SPAs should be subject to management plans considering their potential effects on designated habitats and birds.

8.2 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. 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. Reference points for sustainable outtakes are unknown. In the case of Dundalk the harvest rules applied since 2007 seem to have stabilised stock biomass and maintained productivity.

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.

8.3 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 are probably local 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) and in Drumcliffe Bay (Sligo). 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.

8.4 Management measures

The management measures for the Dundalk fishery are described in 5 year Fishery Natura plans (FNPs; 2011-2016, 2016-2020, 2021-2025) and harvest rules are implemented through annual legislation in the form of Natura Declarations (www.fishingnet.ie). These plans were subject to screening and appropriate assessment as required by the EU Habitats Directive Article 6 and the EU Birds and Habitats Regulations (S.I. 290 of 2013).

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 33).

Annual TAC is set according to harvest control rules set out in the FNP and based on the biomass estimated from a mid-summer survey. There is no fishing at biomass below 1,200 tonnes. Landings are capped at 1,200 tonnes when biomass reaches 2,400 tonnes. At higher biomass levels therefore the harvest rate declines as biomass increases. The cap of 1,200 tonnes is to avoid bumper years which could de-stabilise the market. Depending on overwintering mortality this also helps to support and stabilise fisheries in successive years when recruitment is weak. 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 national minimum legal landing size is 17 mm but operationally and by agreement of the licence holders the minimum size landed in Dundalk Bay 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 oystercatcher and other species of bird that feed on bivalves and the status of characterising bivalve species in intertidal habitats.

8.5 Dundalk Bay

8.5.1 Biomass and landings 2007- 2021

Biomass estimates from annual surveys in 2007-2021 are not strictly comparable because of differences in the time of year in which surveys were undertaken (Table 12). The annual biomass estimates are sensitive to the timing of in year settlement and seasonal mortality of established cohorts relative to the time in which the surveys are undertaken. 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 and was between 3,420-3,790 tonnes in 2019-2020. No fishery has occurred when the biomass was less than 1,032 tonnes (2015). In years when the fishery is opened the TAC uptake has varied from 15 % (2009) to 100 % (2017-2021). This depends on distribution of biomass and the commercial viability of fishing and market prices. The TAC was lower than allowed for in the fishery plan in 2020 by agreement with industry.

Table 12. Annual biomass, TAC and landings of cockles in Dundalk Bay 2007-2021.

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
2020	June	3,420	870	1,128	1,128	0
2021	June	1,927	406	642	638	0

8.5.2 Survey in 2021

8.5.2.1 Biomass

A pre-fishery survey was completed in late May-early June 2021. The survey area was 27.6 km^2. Total biomass was 1,927 tonnes (Table 13) based on a geostatistical model. Biomass of cockles over 22 mm was 1,694 tonnes (Figure 33).

Table 13. Biomass of cockles in Dundalk Bay in May-June 2021.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Biomass All sizes	1,927	2,041	1,796	2,333
Biomass (tonnes) > 22mm	1,695	1,830	1,586	2,094
Biomass (tonnes) > 18mm	1,745	1,971	1,764	2,218
Biomass (tonnes) < 18mm	56	63	50	79

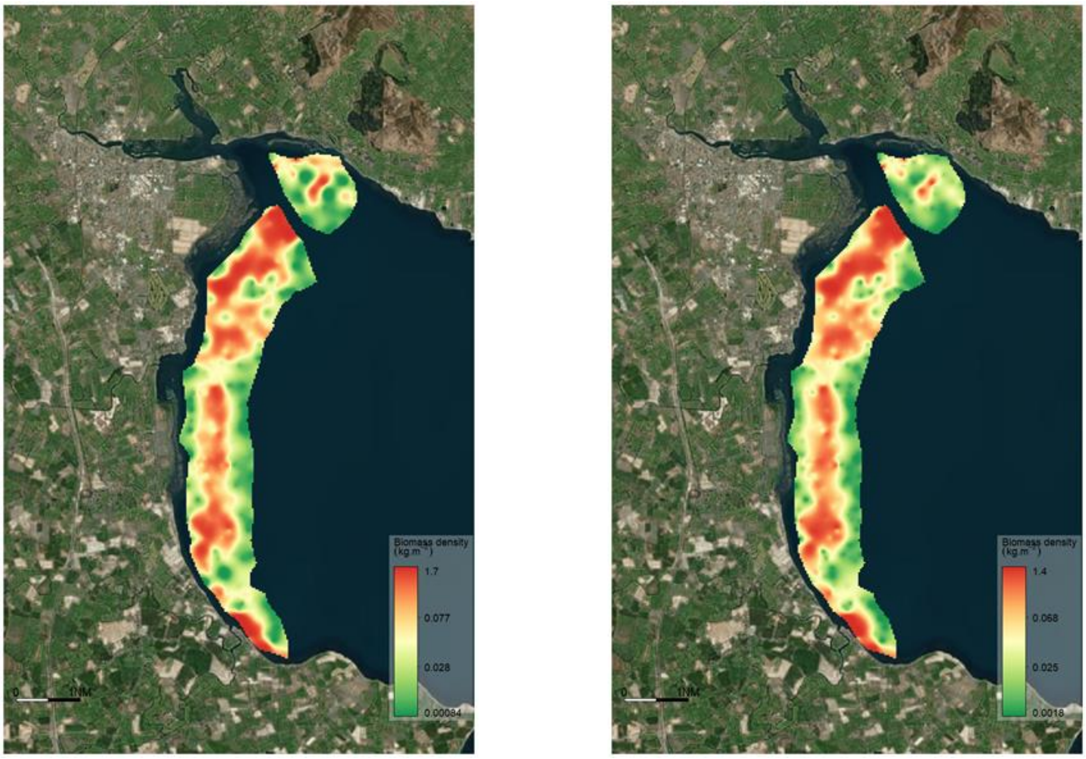

Figure 33. Distribution and density (kgs.m^{-2}) of all cockles (left**) and commercial cockles (>22 mm shell width) (**right**) in Dundalk Bay in May-June 2021.**

8.5.2.2 Size distribution and recruitment

Comparison of the 2018-2021 data shows growth of the 2018 0+ cohort to a modal size of approximately 18 mm in 2019, to 22 mm in 2020 and to 25 mm in 2021 (Figure 34). No significant recruitment (spat settlement) was detected in 2019-2021. The growth of the 2018 cohort lead to an increase in biomass and landings in 2019 and 2020. Biomass was significantly lower in 2021.

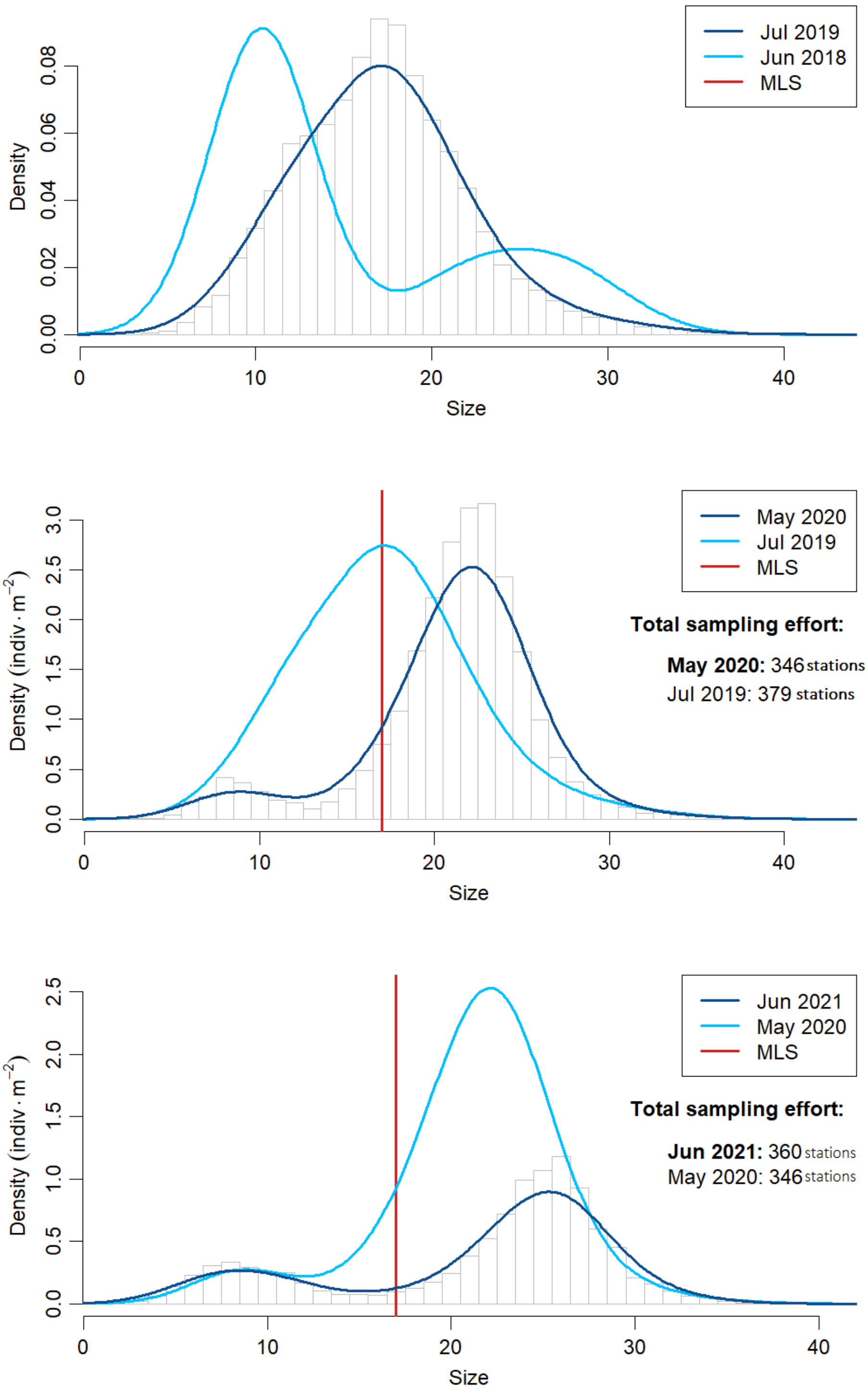

Figure 34. Size distribution of cockles in Dundalk Bay in July 2019 and June 2018, July 2019 and May 2020 and May 2020 and June 2021.

8.5.3 Fisheries monitoring and exploitation rate

In the years 2016-2021 in season depletion in catch rates were observed in 2016 (28 %), 2017 (21 %), 2018 (31 %) and 2021 (50 %) (Figure 35). No depletion was observed in 2019 or 2020 when catches remained close to the 1,000 kg per day limit throughout the season. The level of observed depletion is negatively correlated with pre-fishery biomass. When biomass is high fishing time to take the daily quota is reduced and the fleet can move to different areas to maintain catches. When biomass is lower (1,800-2,300 tonnes in 2016-2018, 2021) the fleet is less able to maintain catches. The observed depletions or absence of depletion indicates that, other than in 2021 when depletion was approximately 50%, generally the 33 % harvest rule is not broken (depletions were 21-31 % in 2016-2018). The depletion rates also suggest that generally the pre-fishery survey correctly estimates the biomass which is used to estimate the TAC. The survey estimate in fact is likely to underestimate the fishable biomass at the start of the fishing season as there is a significant increase in cockle size between the survey and opening of the fishery even if this is usually only 3-6 weeks. This could explain the less than expected depletion rates in years other than 2021.

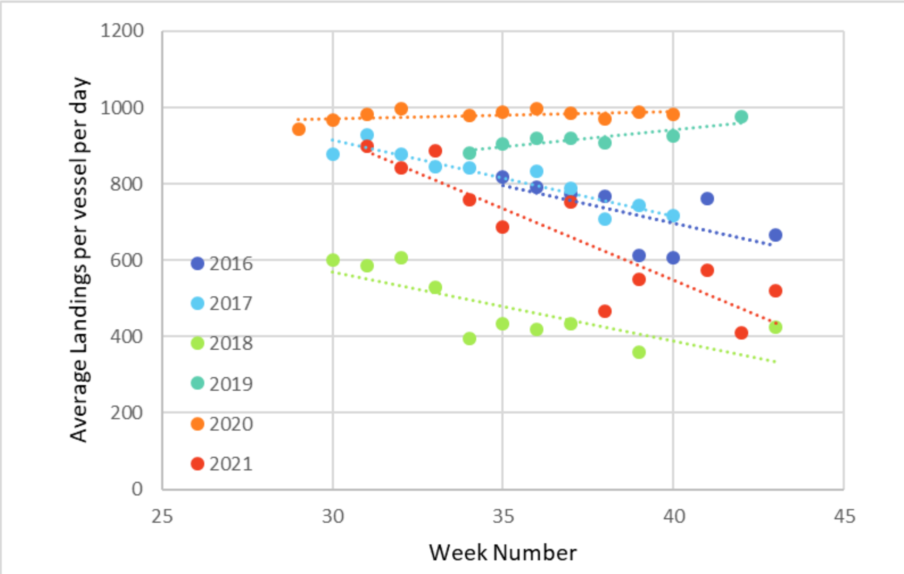

Figure 35. In season changes in average landings per vessel per day grouped by week for each week of the cockle fishery in 2016-2021.

8.5.4 Review of ecosystem effects

Two five-year Fishery Natura Plans (FNP) (2011-2015 and 2016-2020) for Cockles (*Cerastoderma edule*) in Dundalk Bay SAC and SPA have been implemented and a new FNP for the period 2021-2025 was established prior to the fishery in 2021. The FNPs include a requirement to monitor effects on the environment and the ecological features for which the Bay was designated under the Habitats and Birds Directives. Data on characterising species in intertidal habitats which are disturbed by cockle fishing is reported here. Data on overwintering water birds were reviewed in 2020 and are not reported here.

8.5.4.1 Intertidal habitats

The three numerically dominant species of bivalve in the intertidal habitat of Dundalk Bay are cockle (*Cerastoderma edule*), *Angulus tenuis* and *Macoma balthica*. The Baltic clam, *Macoma balthica,* is more abundant on the upper shore, cockles mainly occur along the mid shore and *Angulus tenuis* is dominant from the mid to lower shore. The distribution of all 3 species overlap. Previous studies in Dundalk Bay shows that cockle dredging causes mortality of *Angulus* in particular as its shell is lighter compared to the other two species. However, its overall sensitivity to abrasion pressure is low given its short life cycle and high recoverability. *Macoma* is much less exposed to the cockle fishery as it is distributed on the upper shore. Counts of the casts of the polychaete worm, *Arenciola marina* have been recorded since 2013.

The distribution of these species is estimated during the annual summer surveys carried out from 2007-2021. Both *A. tenuis* and *M. balthica* can occur in high densities (Table 14, Figure 36). The average densities of *Angulus tenuis* have increased from 2018 to 2021 while those of *Macoma balthica* have declined year on year since 2018. The distribution of Angulus and Macoma from the 2019, 2020 and 2021 cockle surveys is shown in Figure 37.

Average densities of the lugworm, *Arenicola marina* have shown an overall decrease since 2014 when the highest densities of 11.62 per square meter were recorded. However, average densities of *A. marina* in 2021 have increased slightly from 2020 (Table 14).

Table 14. Mean density (m^{-2}) of the bivalves *Angulus tenuis*, *Macoma balthica* and the polychaete worm *Arenicola marina*, along with the average Redox potential discontinuity layer in intertidal habitats during the mid-summer cockle surveys 2011-2021.

Year	*Angulus tenuis*		*Macoma balthica*		*Arenicola marina*		Redox Potential Discontinuity (RPD) layer	
	Average	S.d.	Average	S.d.	Average	S.d.	Average	S.d.
2011	26.14	38.74	13.98	36.25			9.43	4.63
2012	55.35	62.18	17.74	41.21				
2013	95.43	89.82	28.10	57.49	6.43	8.10	12.74	7.08
2014	91.61	83.19	18.53	42.23	11.62	9.18	18.66	10.8
2015	70.56	76.90	18.80	40.06	6.08	5.33	9.34	6.00
2016	83.33	75.07	19.41	51.29	6.26	4.82	11.21	6.28
2017	67.89	90.11	12.39	30.15	5.58	4.45	10.11	4.43
2018	77.89	88.09	24.64	51.15	4.35	3.10	10.27	6.81
2019	84.66	86.40	22.91	48.60	5.26	3.27	10.43	6.13
2020	87.51	99.59	18.72	42.77	3.49	3.15	9.981	7.29
2021	88.27	85.2	14.56	28.73	4.27	3.65	10.44	4.96

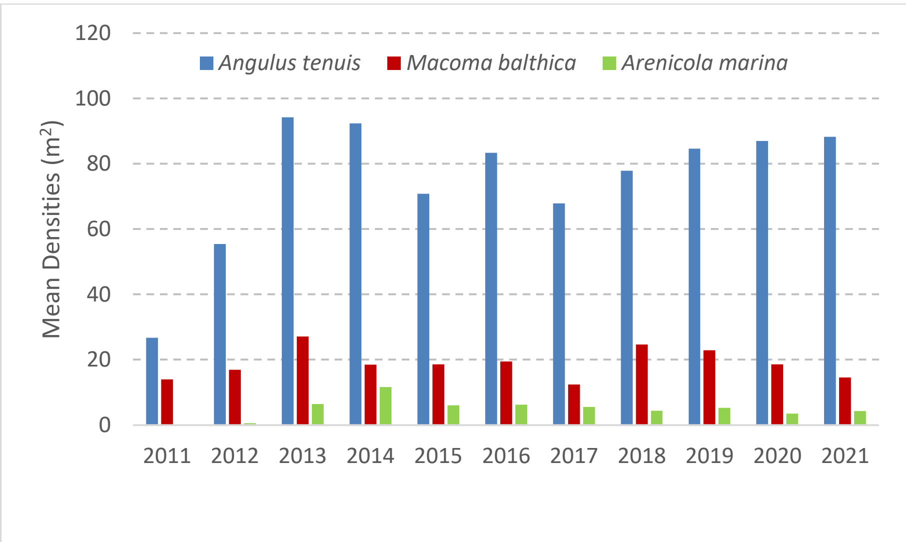

Figure 36. Mean densities of *Angulus tenuis*, *Macoma balthica* and *Arenicola marina* in intertidal sediments in Dundalk Bay 2011-2021.

The divide between the surface oxygenated and sub-surface anaerobic sediment is known as the redox potential discontinuity (RPD) layer. This divide appears as a grey layer of sediment above the black deoxygenated sediment below. Sediment mobility and biological bioturbation caused by feeding of infaunal deposit feeders increases oxygen supply to sediments and thus makes the oxygenated surface layer of sediment deeper. Eutrophication and increased biological oxygen demand in the sediment reduces oxygen availability and the RPD layer can then occur very close to the sediment surface. Filter feeding bivalves such as cockles occur above the RPD or at least must reach the aerobic layer when feeding. The depth of the RPD was measured at each station during the summer surveys from 2011 to 2021 (Table 14). It has been consistent at an average depth of about 10 cm since 2015.

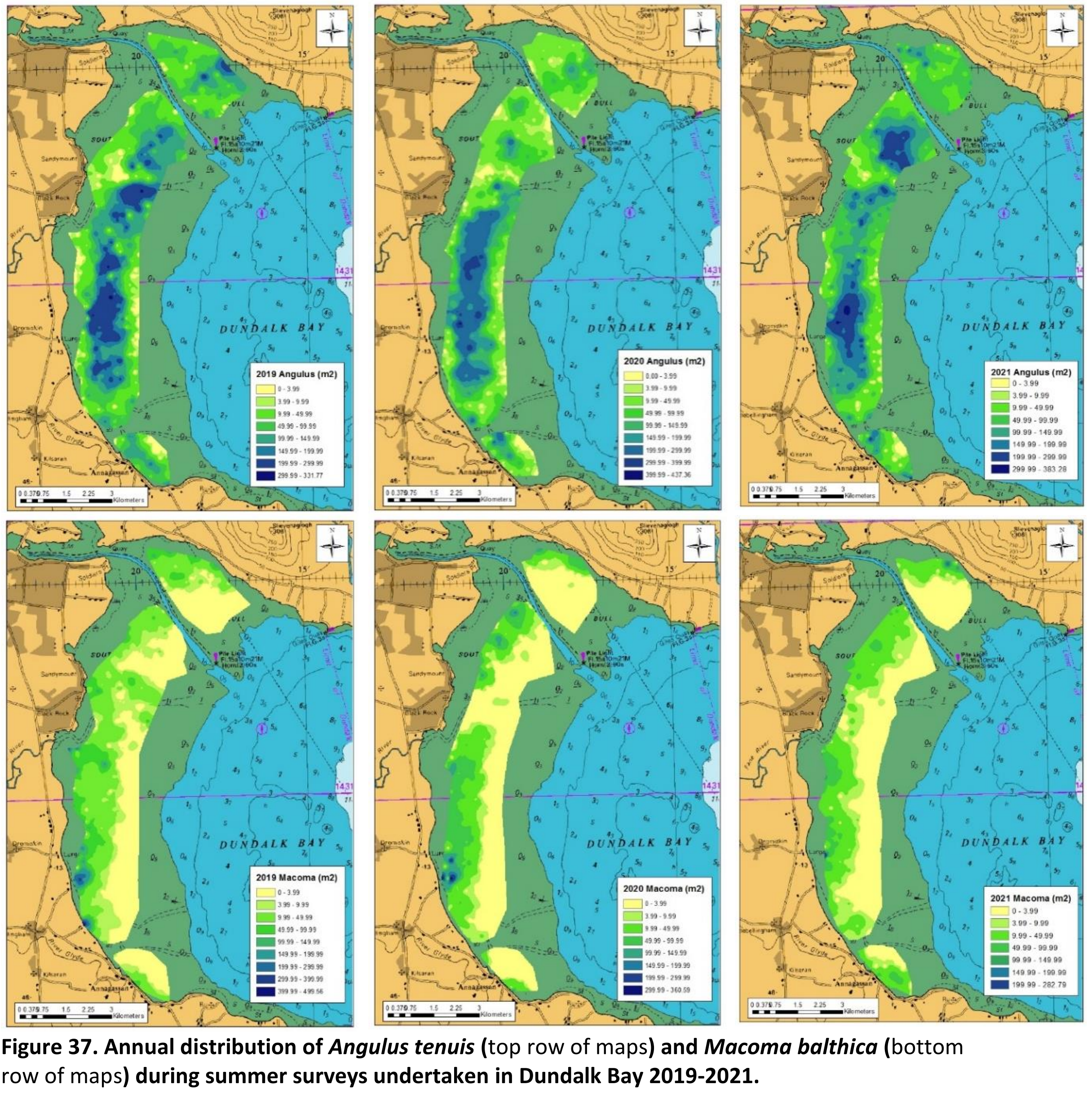

Figure 37. Annual distribution of *Angulus tenuis* (top row of maps**) and *Macoma balthica* (**bottom row of maps**) during summer surveys undertaken in Dundalk Bay 2019-2021.**

9 Oyster (*Ostrea edulis*)

9.1 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, 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 to allow for growth and use of various stock recovery 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.

9.2 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. Inner Tralee Bay 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. Increases in freshwater inflows to estuaries in inner Galway Bay reduces the area of suitable oyster habitat.

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 or based on the annual surveys.

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 Galway Bay, Cill Chiaráin Bay, Tralee Bay and Clew Bay. Dredging may damage these communities. Management of oyster fisheries needs to consider the conservation objectives for oyster 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.

9.3 Management units

Oyster stocks occur as discrete stock 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.

9.4 Survey methods

Oyster beds are surveyed annually by dredge. Dredge designs vary locally and these 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. Separate estimates were obtained in 2021 in Lough Swilly by quantitative quadrat sampling at low tide followed by dredge sampling in the same area at high water. Biomass is estimated using a geostatistical model accounting for spatial autocorrelation in the survey data.

9.5 Inner Tralee Bay

9.5.1 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, 2018 and 2020. The area surveyed usually contains the entire stock which is distributed over approximately 4 km^2 (Table 15). The biomass reported in 2020 was the highest in the time series. The larger area sampled along with the considerably shorter haul lengths recorded and the distribution of the tracks over the survey area in 2020 compared to other years suggest that the 2020 estimate may not be comparable to other years. A different pattern in haul lengths was also observed between 2017 and 2018, which may also have affected density and biomass estimates. Other than 2020 annual biomass estimates for all size classes of oysters and corrected for dredge efficiency has varied from just over 600 tonnes to over 1,000 tonnes.

Table 15. Stock biomass trends for native oyster in Inner Tralee Bay 2010-2021.

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	1,265
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	1,161
2019	October	3.7	237.57	879
2020	September	5.32	304.14	1,618
2021	September	4.05	152.35	617

9.5.2 Survey September 2021

A pre fishery survey was carried out on the 7-8th September in Inner Tralee Bay. A total of 75 tows were undertaken, with a single toothless dredge of width 1.22 m. GPS data for each tow track was recorded on a Trimble GPS survey unit and swept area for each tow was estimated. The survey encompassed an area of 4.05 km^2 east of Fenit pier (Figure 38).

9.5.2.1 Distribution and Biomass in 2021

Biomass of oysters uncorrected for dredge efficiency varied from 0-0.18 $kgs.m^{-2}$ (Figure 38). Biomass of oysters over 76 mm ranged from 0-0.02 $kgs.m^{-2}$.

Total biomass of oysters, assuming a dredge efficiency of 35 %, was 617 tonnes (Table 16). The equivalent biomass of oysters 76 mm or over was 176 tonnes (Table 16) or approximately 29 % of the total biomass.

Table 16. Distribution of oyster biomass in Inner Tralee Bay in September 2021.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_Ostrea_edulis	216.0	262.0	215.20	316.0
Biomass_>76mm_Ostrea_edulis	61.5	89.9	64.3	117.0
Corrected_35% Dredge Efficiency				
Biomass_Ostrea_edulis	617.0	751.0	600.0	902.0
Biomass_76_Inf_Ostrea_edulis	176.0	253	182	342.0

Figure 38. Distribution and biomass of native oyster in Inner Tralee Bay from the September 2021 survey (uncorrected for dredge efficiency).

9.5.2.2 Size distribution 2021

The size distribution of oysters caught during the survey shows a strong mode at 60-70 mm and a smaller less defined mode at 30-40 mm (Figure 39). There is no evidence of modal progression (growth) between 2020 and 2021. Densities of all size categories are significantly lower in the 2021 survey compared to the 2020 survey and is reflected in the overall lower biomass estimate in 2021.

Future prospects for the stock remain strong given that all size classes from 50-78 mm are well represented in the stock. Mortality rates on oysters below 78 mm appear to be low.

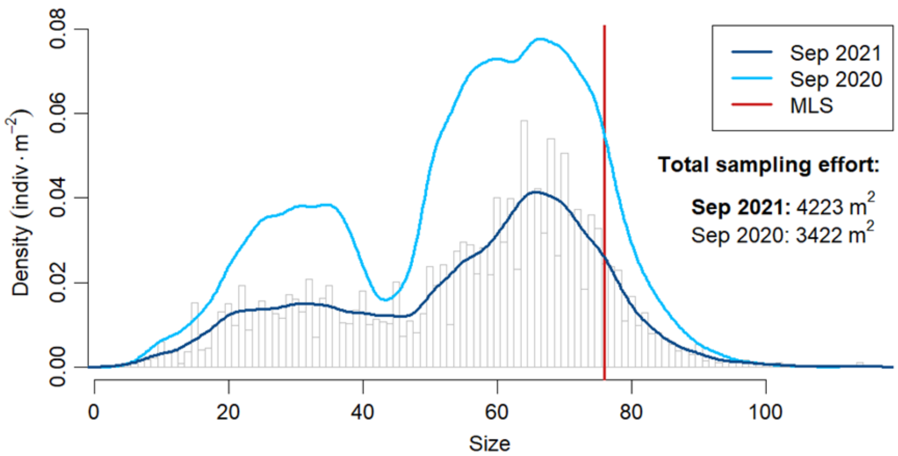

Figure 39. Size distribution of native oysters in the Inner Tralee oyster bed in September 2021. The MLS (76 mm) is also shown. Data are standardised to sampling effort regardless of its spatial distribution.

9.6 Outer Tralee Bay

9.6.1 Stock trends

The oyster beds in Outer Tralee Bay are not surveyed annually and the survey area has varied over time (Table 17). An initial survey of the outer Tralee oyster beds was undertaken in September 2010. Two beds were surveyed, Corkerys Bed, close to the landward edge of the middle of Tralee Bay and the Maharees bed just off the coast from the Maharees tombolo. Both areas were assessed separately in February 2012. However subsequent surveys have amalgamated both beds and assessed them as the outer Tralee Bay oyster bed. Stocks in outer Tralee Bay have varied year on year with the highest biomass being reported in February 2016.

Table 17. Stock biomass trends for native oyster in Outer Tralee Bay 2010-2021.

Year	Month	Survey Area (km^2)	Biomass km^{-2}	Biomass (tonnes)
2010	September	3.63	27.40	99.47
2012	February (Corkerys Bed)	1.38	50.43	69.6
2012	February (Maharees Bed)	2.3	86.86	199.78
2014	September	7.68	26.61	204.08
2016	February	8.34	34.24	285.56
2020	September	9.0	48.3	150.9
2021	September	8.0	10.75	86.0

9.6.2 Survey October 2021

A pre fishery survey was carried out on the 15th September on the outer Tralee Bay oyster bed. A total of 69 tows were undertaken, with a single toothless dredge of width 1.22 m. GPS data for each tow track was recorded on a Trimble GPS survey unit and swept area for each tow estimated. The survey encompassed an area of 8 km^2 (Figure 40).

9.6.2.1 Distribution and Biomass in 2021

Biomass of oysters uncorrected for dredge efficiency varied from 0-0.037 $kgs.m^{-2}$ (Figure 40), while the biomass of oysters over 76 mm ranged from 0-0.00432 $kgs.m^{-2}$.

Total biomass of oysters, assuming a dredge efficiency of 35 %, was 86 tonnes (Table 18). The equivalent biomass of oysters 76 mm or over was 46 tonnes (Table 18) or approximately 50 % of the total biomass.

Table 18. Distribution of oyster biomass, corrected for a dredge efficiency of 35%, in outer Tralee Bay in September 2021.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_Ostrea_edulis	30.10	31	23.2	41.8
Biomass_>76mm_Ostrea_edulis	16.2	22.9	15.9	31.2
Corrected_35% Dredge Efficiency				
Biomass_Ostrea_edulis	86	89.3	62.70	115.0
Biomass_76_Inf_Ostrea_edulis	46.2	66.5	49.8	89.9

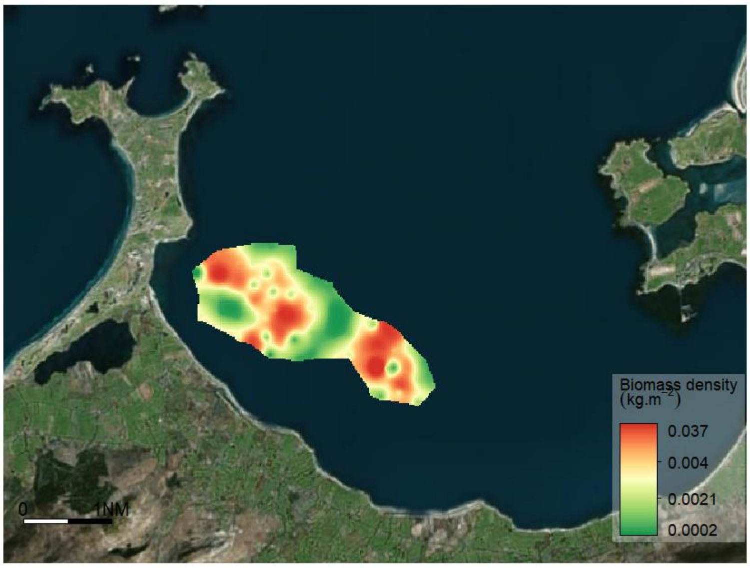

Figure 40. Distribution and biomass of native oyster in Outer Tralee Bay in September 2021 (uncorrected for dredge efficiency).

9.6.2.2 Size distribution

The size distribution of oysters caught during the survey show higher densities between 60-80 mm than in smaller size classes (Figure 41). Approximately 29 % of the oysters were above the minimum landing size of 76 mm. There is no evidence of significant mortality of oysters in sizes classes between 60-76mm as is evident in other stocks and the high densities above the minimum size is also unusual in both fished and unfished stocks in areas infected with Bonamia.

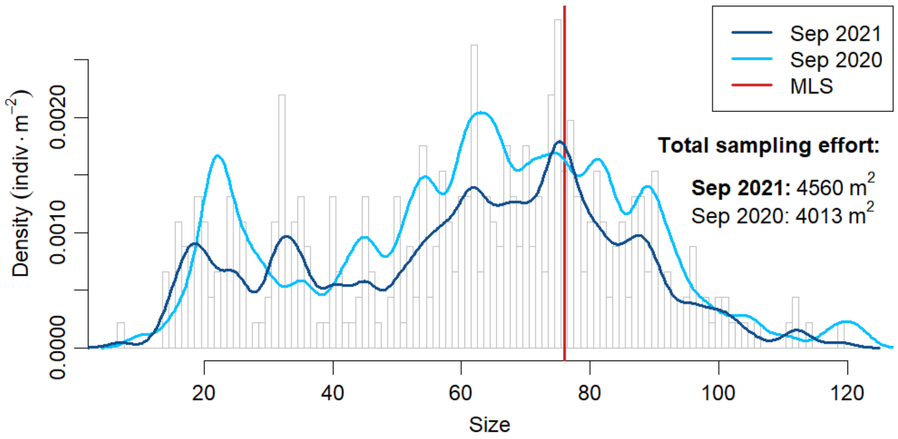

Figure 41. Size distribution of native oysters in Outer Tralee Bay oyster bed in September 2021. The MLS (76 mm) is also shown. Data are standardised to sampling effort regardless of its spatial distribution.

9.7 Galway Bay

9.7.1 Stock trends

Annual surveys have been undertaken on the Inner Galway Bay oyster beds since 2011 with the exception of 2020 (Table 19). The area surveyed for oysters has varied over the years with the main bed located between Eddy Is. and Rincarna Bay being surveyed most frequently. Oyster biomass in inner Galway Bay has declined in recent years. The main issue seems to be high mortality rates in oysters over 60 mm unrelated to fishing mortality.

Table 19. Stock biomass trends for native oyster in Inner Galway Bay 2010-2021.

Year	Month	Survey Area (km^2)	Biomass km^{-2}	Biomass
2011	April	2.46	14.05	34.56
2012	February	1.17	24.52	28.69
2012	November	1.11	49.77	55.25
2013	November	1.02	42.94	43.8
2014	November	0.91	65.12	59.26
2016	March	0.73	106.85	78
2017	November	0.71	148.59	105.5
2018	October/November	0.72	97.78	70.4
2019	October/September	0.97	8.79	8.53
2021/2022	November/January	2.3	59.39	136.6

9.7.2 Survey November 2021 – January 2022

A survey of the oyster beds of Inner Galway Bay (Rincarna and St. Georges beds) was carried out on the 19th November 2021 and on the 14th and 21st January 2022. A total of 94 tows were undertaken using a single toothless dredge of width 1.2 m. GPS data for each track was recorded on a Trimble GPS survey unit and the swept area for each tow estimated. The survey encompassed a combined area of 2.3 km^2 within Galway Bay with a total sampling effort of 6,369 m^2.

9.7.2.1 Distribution and Biomass in late 2021/early 2022

Biomass of native oysters (*Ostrea edulis*), uncorrected for dredge efficiency and including all sizes, varied from 0.00011-0.31 kgs.m^{-2} (Figure 42). These estimates were higher in the south part of the St. Georges bed (Figure 42). Biomass of native oysters over 76 mm ranged from 0.00005 - 0.021 kgs.m^{-2} and were higher in the south of the survey area.

The biomass of native oysters, assuming a dredge efficiency of 35 % was 136 tonnes (Table 20). The equivalent biomass of oysters over 76 mm was 6.9 tonnes (Table 20) indicating that the biomass of commercial size is 5 % of the total stock. The size distribution data indicate that mortality rates between 56-76 mm are high. Normally numbers would be stable up to the minimum landing size and then decline exponentially due to fishing. The mortality could be due to *Bonamia* or environmental conditions. *Bonamia* prevalence was 10-20 % in the surveyed area in 2021.

Table 20. Distribution of oyster biomass, corrected for a dredge efficiency of 35 %, in Inner Galway Bay (Rincarna and St. Georges Bed) in November 2021 and January 2022.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_Ostrea_edulis	47.8	56.0	41.7	75.87
Biomass_>76mm_Ostrea_edulis	2.74	4.57	1.78	37.8
Corrected_35% Dredge Efficiency				
Biomass_Ostrea_edulis	136.6	160.8	120.3	216.8
Biomass_76_Inf_Ostrea_edulis	6.9	12.5	5.11	85.8

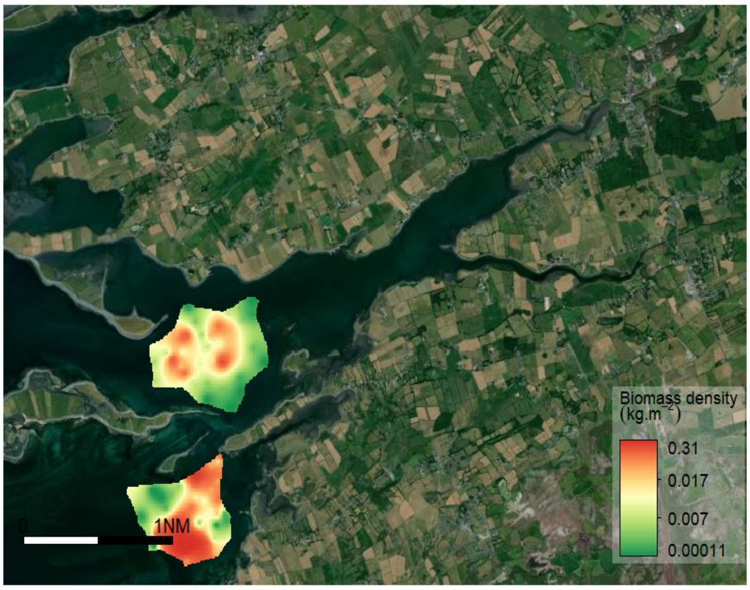

Figure 42. Distribution and biomass of native oyster (uncorrected for dredge efficiency) in Inner Galway Bay, November2021 and January 2022.

9.7.2.2 Size distribution

The size distribution of oysters sampled during the survey showed a strong mode at ~45 mm (Figure 43). Few individuals above the 76 mm minimum landing size were found. No strong indication of recruitment (spat) was observed.

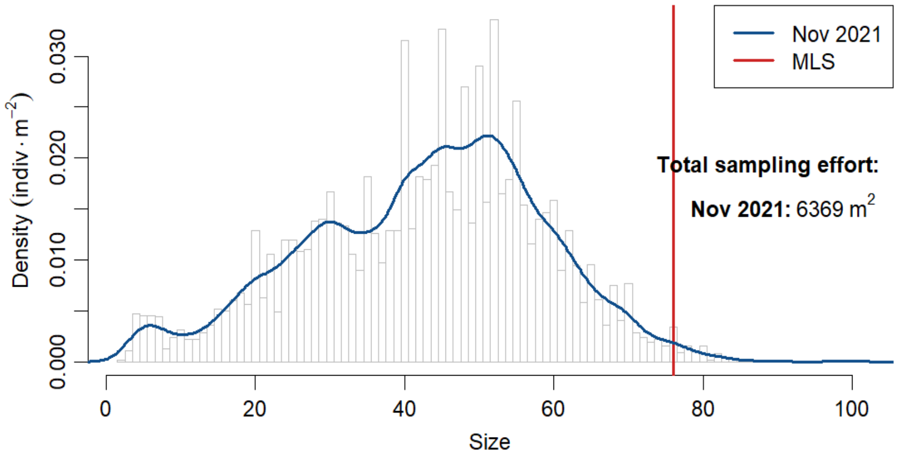

Figure 43. Size distribution of native oysters in the Inner Galway Bay in November 2021/January 2022. The MLS (76 mm) is also shown. Data are standardised to sampling effort regardless of its spatial distribution.

9.8 Cill Chiaráin

9.8.1 Stock trends

Five surveys were out by the Marine Institute on the Cill Chiaráin oyster beds prior to October 2021 (Table 21). Prior to 2010 Taighde Mara Teo and BIM 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 (cultching) occurred at that time but ceased in 1998.

Table 21. Stocks biomass trends for native oyster in Cill Chiaráin 2010-2020.

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
2020	October	2.86	48.3	138.07
2021	October	2.00	10.01	20.02

9.8.2 Survey October 2021

A survey was carried out on October 13-14th in Cill Chiaráin Bay. A total of 81 tows were undertaken (80 valid), with a single toothless dredge of width 1.16 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 2.0 km^2 within Cill Chiaráin Bay with a total sampling effort of 5,307 m^2.

9.8.2.1 Distribution and Biomass in 2021

Biomass of oysters uncorrected for dredge efficiency varied from 0-0.075 $kgs.m^{-2}$, with the highest biomasses in the centre and south-east beds of the survey area (Figure 44). Biomass of oysters over 76 mm ranged from 0-0.011 $kgs.m^{-2}$ and had a similar distribution pattern.

The biomass of oysters, assuming a dredge efficiency of 35% in October was 20 tonnes (Table 22). The equivalent biomass of oysters 76 mm or over the national minimum landing size was 3.4 tonnes or 17% of the stock (Table 22).

The biomass estimated in 2021 was lower than the 138 tonnes estimated in October 2020. The decrease in biomass is unlikely to be due to natural or fishing mortality. Catchability during the survey and access to all known beds is problematic in the area and biomass estimates are very uncertain at this point.

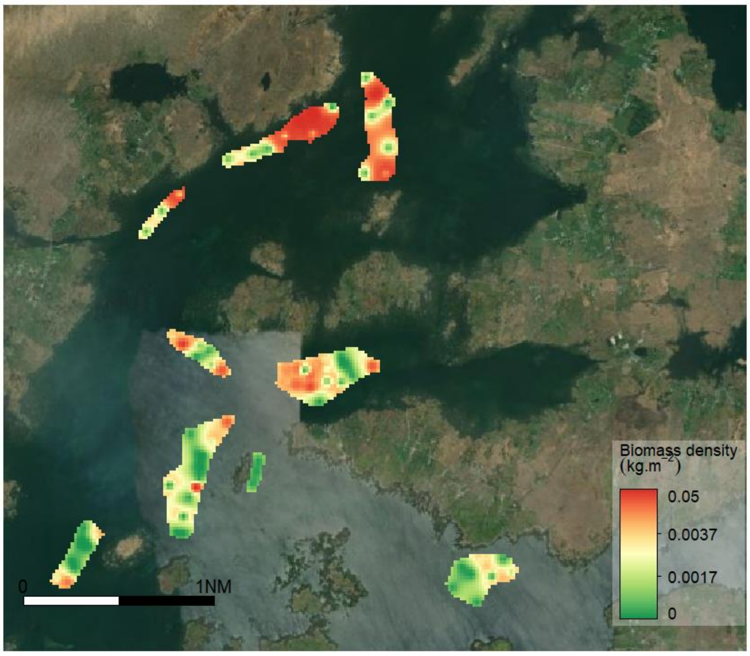

Figure 44. Distribution and biomass of native oyster in Cill Chiaráin in October 2021 (uncorrected for dredge efficiency).

Table 22. Biomass of native oyster in Cill Chiaráin in October 2021 based on a dredge efficiency of 35 %.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_Ostrea_edulis	7.15	8.59	3.55	15.33
Biomass_>76mm_*Ostrea_edulis*	1.19	1.32	0.74	2.06
Corrected for 35% Dredge Efficiency				
Biomass_Ostrea_edulis	20.02	24.58	9.25	44.44
Biomass_>76mm_*Ostrea_edulis*	3.14	3.76	1.92	5.89

9.8.2.2 Size distribution

The size distribution of oysters caught during the October 2021 survey shows a similar pattern to 2020 (Figure 45), however fewer oysters were sampled due to small catches. The size data in 2021 shows higher numbers of oysters in the 50-70mm size classes. There was no evidence of in year recruitment.

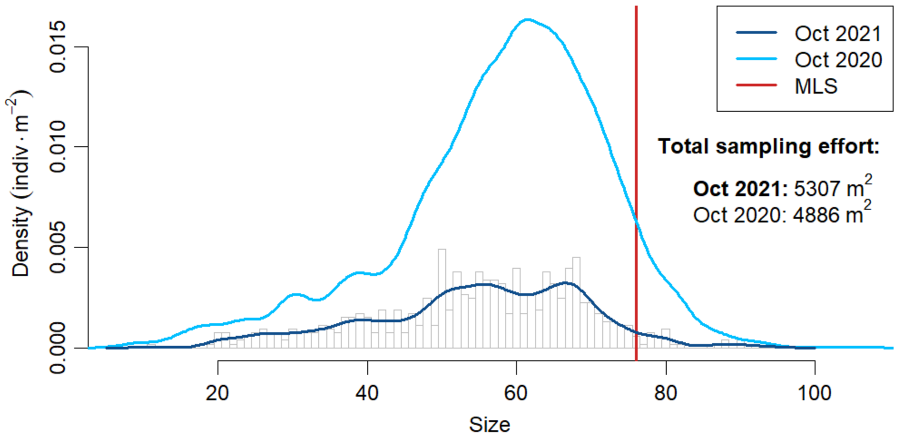

Figure 45. Size distribution of native oysters (*Ostrea edulis*) in Cill Chiaráin in October 2020 and October 2021. The minimum landing size (76 mm) is shown. Data are standardised to sampling effort regardless of its spatial distribution.

9.9 Lough Swilly

A survey of native (*Ostrea edulis*) and Pacific oysters (*Magallana gigas*), consisting of 155 dredge hauls, was undertaken in Lough Swilly on November 16th and December 15-16th 2021 using two single toothless dredges of width 1.5 m and 1.2 m, respectively.

9.9.1 Native Oyster (*Ostrea edulis*)

9.9.1.1 Stock trends

The area covered by the surveys has varied significantly during the time series which compromises inter year comparisons (Table 23). Surveys from 2011-2021 standardised for survey area show that native oyster biomass per square kilometre of survey area varied from 6-44 tonnes. The biomass.km^{-2} (26-43 tonnes) was higher in 2017, 2018 and 2020 than previous years, however a lower estimate of 13.6 tonnes.km^{-2} was recorded in 2021.

Table 23. Stocks biomass trends for native oyster at Lough Swilly 2011-2021.

Year	Month	Survey Area (km^2)	Biomass km^{-2}	Biomass
2011	March	1.56	25.64	40
2011	November	13.07	9.52	124
2012	October	11.48	15.46	177
2013	October	5.96	14.14	84
2014	October	13.19	15.85	209
2015	August	5.19	6.50	33
2016	August	5.58	17.40	97
2017	September	7.19	43.99	316
2018	April	7.81	26.48	207
2020	July	10	31.78	318
2021	Nov-Dec	8.1	13.64	110.5

9.9.1.2 Distribution and Biomass in 2021

Biomass of native oysters (*Ostrea edulis*), uncorrected for dredge efficiency and including all sizes, varied from 0-.00037-0.028 kgs.m^{-2}. Abundance and biomass was higher in the upper Lough (Figure 46) . Biomass of oysters over 76 mm ranged from 0 - 0.014 kgs.m^{-2}.

The biomass of native oysters, assuming a dredge efficiency of 35 % was 110 tonnes (Table 24). The equivalent biomass of oysters 76 mm or over the national minimum landing size was.

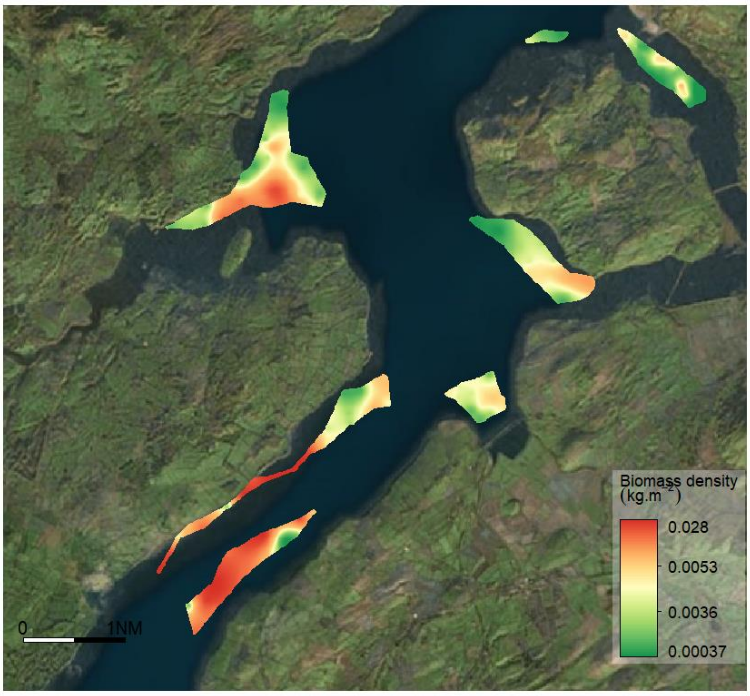

Figure 46. Biomass of native oysters in Lough Swilly, November-December 2021 (uncorrected for dredge efficiency).

Table 24. Distribution of native oyster biomass, uncorrected and corrected for a dredge efficiency of 35 %, Lough Swilly, November-December 2021. Data from all oyster beds were combined.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_Ostrea_edulis	38.6	49.1	41.6	59.11
Biomass_>76mm_Ostrea_edulis	4.2	5.6	3.3	8.7
Corrected_35% Dredge Efficiency				
Biomass_Ostrea_edulis	110.5	139.5	116.3	163.7
Biomass_>76mm_Ostrea_edulis	11.9	16.6	9.53	25.8

9.9.1.3 Size distributions

The size distribution of native oysters in the survey showed a mode at approximately 55-65 mm with a few individuals above the 76 mm minimum landing size and a much smaller mode at 4 mm representing new recruitment (Figure 47).

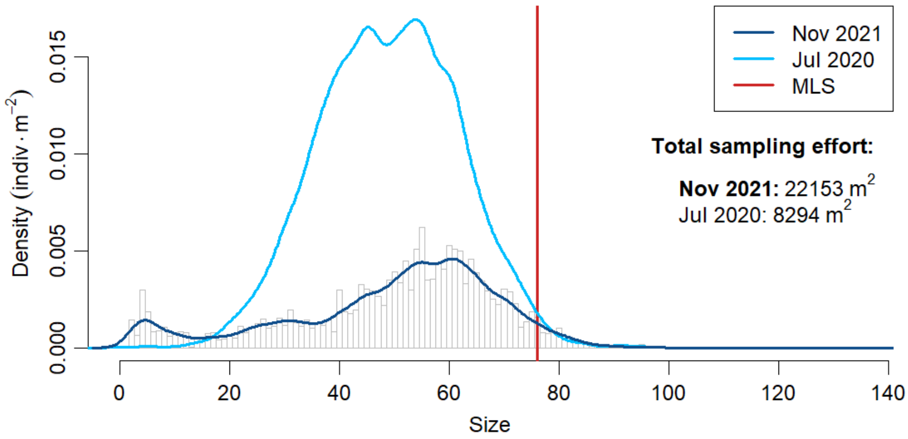

Figure 47. Size distribution of native oysters in Lough Swilly, November –December 2021 (uncorrected for dredge efficiency).

9.9.2 Pacific oyster (*Magallana gigas*)

9.9.2.1 Distribution and Biomass in 2020

Biomass of pacific oysters (*Magallana gigas*) uncorrected for dredge efficiency varied from 0- 0.17 kgs.m^{-2}, with the highest biomasses in the south and north west of the survey area (Figure 48).

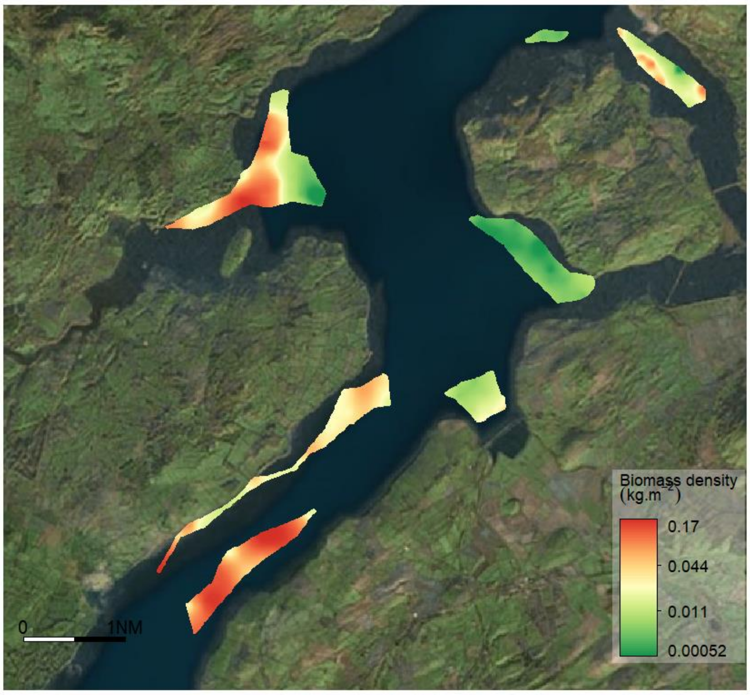

Figure 48. Biomass of pacific oysters in Lough Swilly, November-December 2021 (uncorrected for dredge efficiency).

The biomass of pacific oysters, assuming a dredge efficiency of 35 % was 745.5 tonnes (Table 25). The previous estimate in 2020 was 1,718 tonnes.

Table 25. Distribution of pacific oyster biomass, uncorrected and corrected for a dredge efficiency of 35 %, Lough Swilly, November-December 2021. Data from all oyster beds were combined.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_*Magallana gigas*	261.2	293.7	248.3	339.5
Corrected for 35% Dredge Efficiency				
Biomass_*Magallana gigas*	745.5	836.1	719	984.3

9.9.2.2 Size distributions

The size distribution of Pacific oysters in the survey indicate a strong mode at approximately 70 mm (3 years old) and at 3 mm indicating recent recruitment.

There has been a decline in the prevalence of larger size classes of Pacific oysters since 2018. In 2017 and 2018 two main cohorts were present; model sizes of about 45 mm and 90 mm. The larger cohort was not as evident in the 2020 and 2021 surveys (Figure 49). This reduction is probably due to fishing.

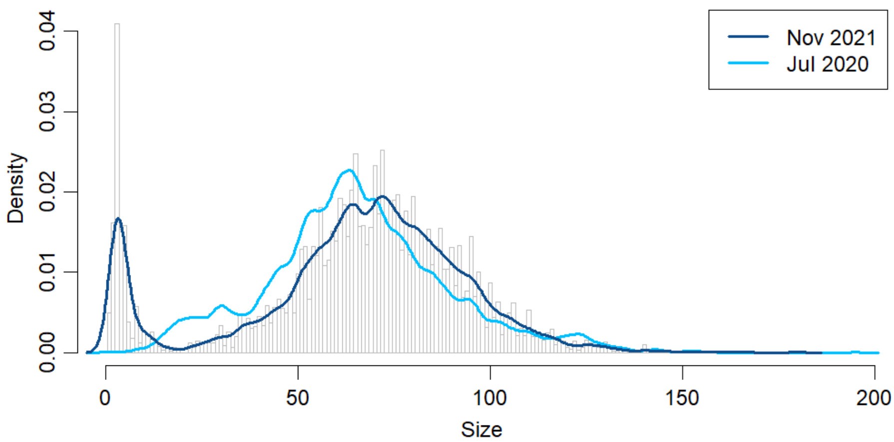

Figure 49. Size distribution of Pacific oyster in July 2020 and November-December 2021, Lough Swilly.

10 Scallop (*Pecten maximus*)

10.1 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.

10.1 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. More 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. 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.

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.

10.2 Management units

Offshore scallop stocks in the Irish Sea, Celtic Sea and Western and Eastern English Channel are spatially discrete following settlement (Figure 50), 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.

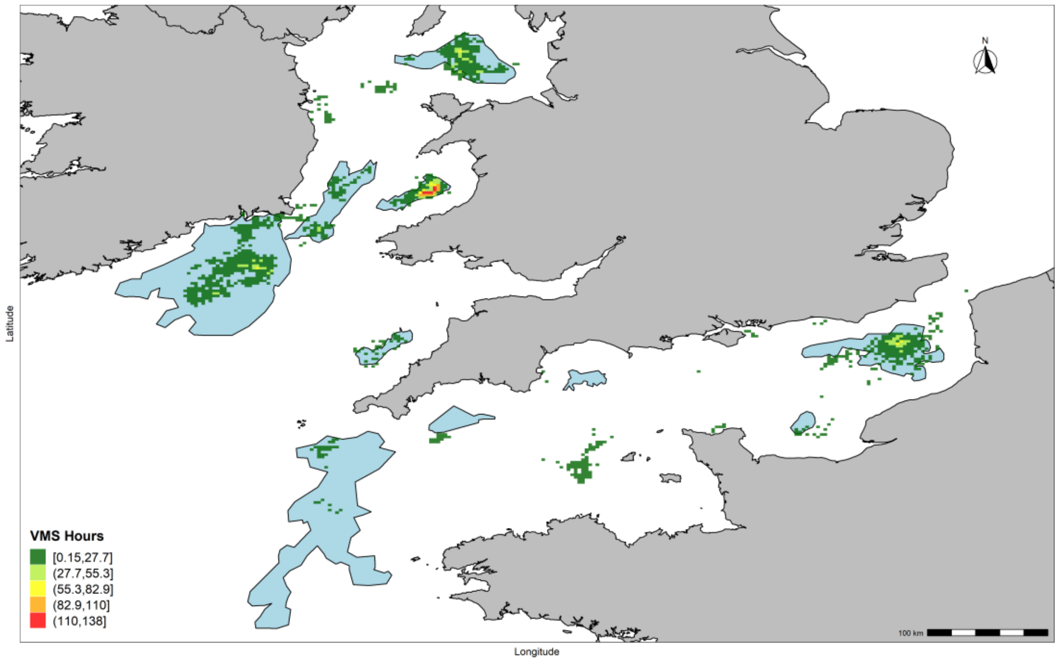

Figure 50. Scallop grounds fished by the Irish fleet in the Irish Sea, Celtic Sea and English Channel. Boundaries are defined from the distribution of fishing activity by the Irish fleet 2000–2015 as shown by VMS data and some UK VMS data. The stock boundary limits are likely to be larger particularly 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 2021 (raster 3 km^2 grid) are shown relative to the spatial extent of the stocks that are fished.

10.3 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 51). Since 2012 the number of dredges in the fleet varied from 198-230 compared to the estimated 522 dredges prior to the decommissioning of part of the fleet in 2006. The number of dredges in the fleet have declined since 2017. 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.

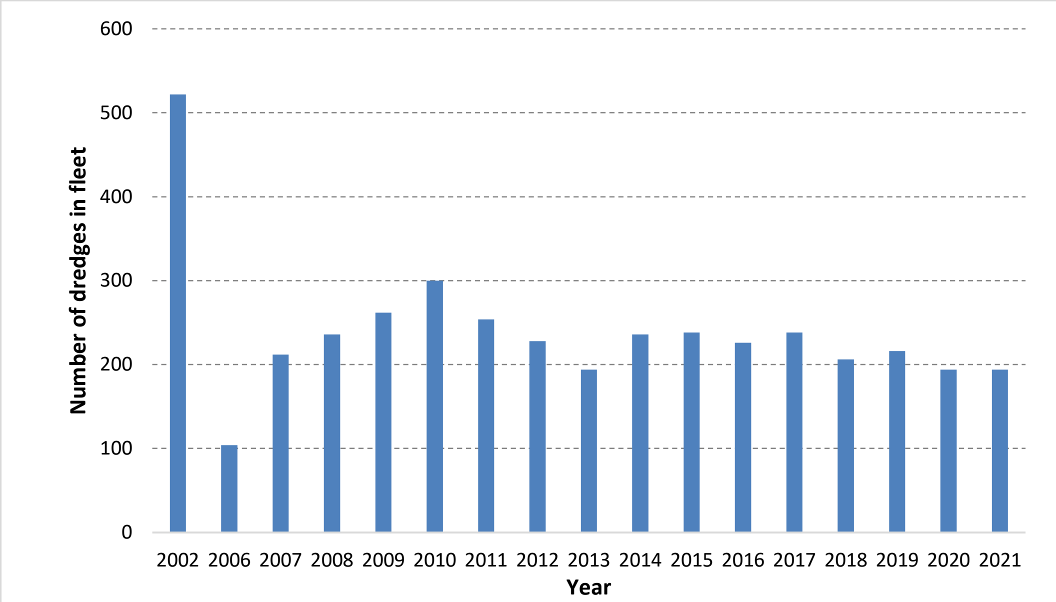

Figure 51. **Annual estimated number of dredges in the authorised Irish fleet of scallop vessels over 10 m, 2002 and 2006–2021 based on the relationship between vessel length and number of dredges (Dredges = 0.88 * Boat length). The fleet was partly decommissioned in 2006**.

10.4 Offshore scallop fisheries

10.4.1 Landings

Landings increased from 1995–2004 due to fleet expansion of the geographic areas fished, particularly in the Celtic Sea (Figure 52). 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. Other than in 2020 total landings have remained above 2,000 tonnes per annum since 2013 (Figure 52).

The Irish fleet fishes in the Celtic Sea, English Channel and the Irish Sea south of the Isle of Man (Figure 50). The majority of landings by Irish vessels are usually from the Celtic Sea, although the Eastern English Channel has become an increasingly important area for the fleet in recent years (Figure 52). The increase in landings from the Eastern English Channel since 2016 is correlated with a decline in landings from the Irish Sea (Figure 52).

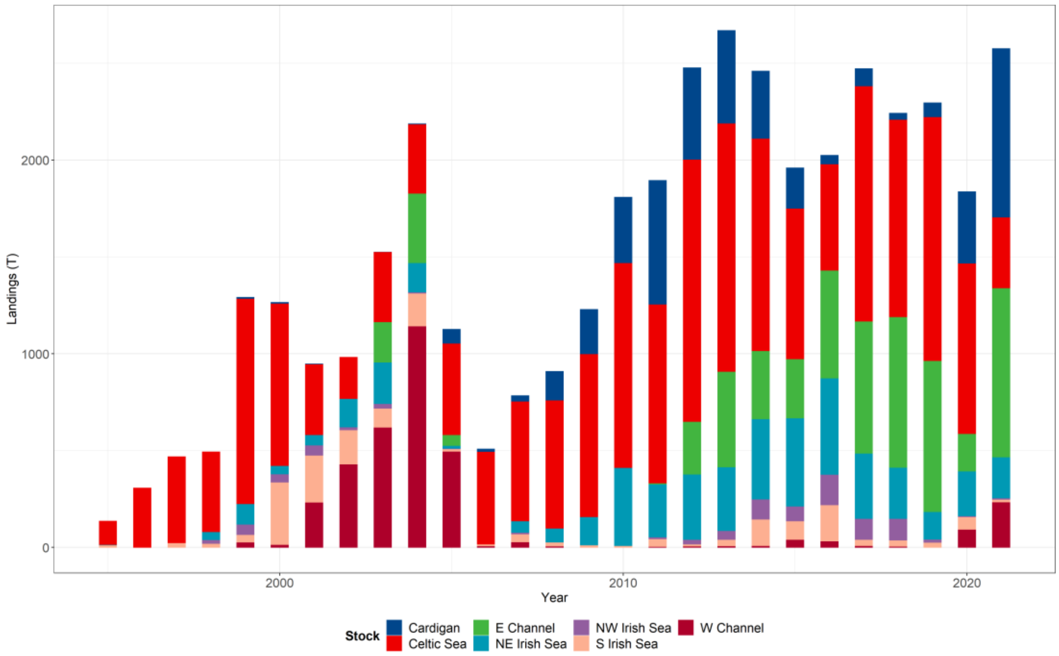

Figure 52. Annual landings of scallop by the Irish fleet from stocks in the Celtic Sea, Irish Sea and English Channel areas 1995–2021.

10.4.2 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 53). 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 53) 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.

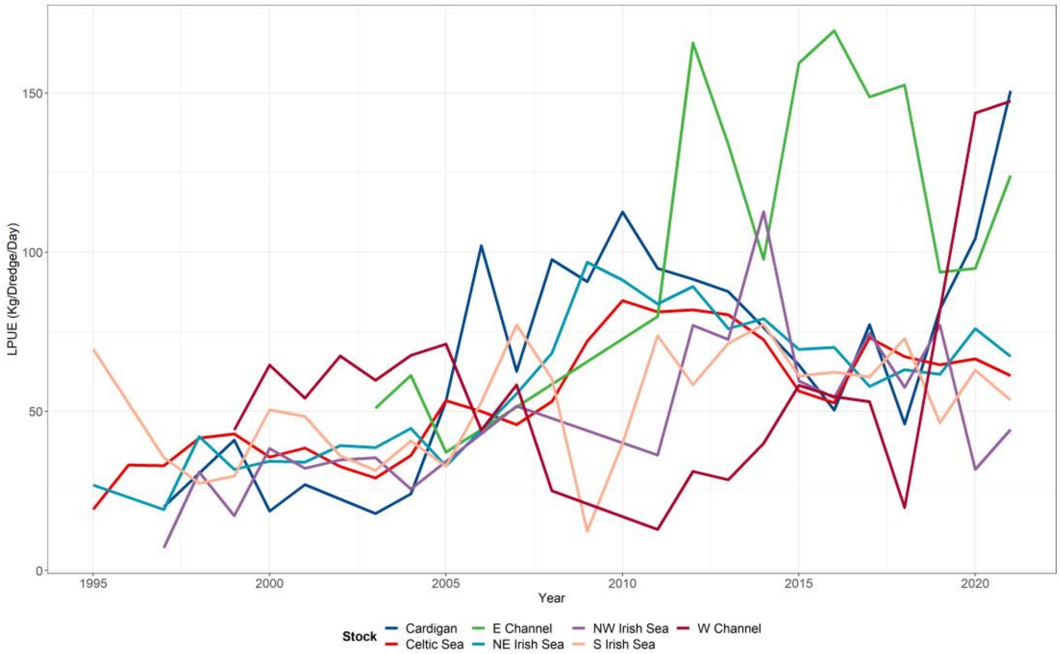

Figure 53. Annual average catch rate (kgs.dredge^{-1}.day^{-1}) from the main scallop stocks fished by the Irish fleet 1995–2021.

10.5 Scallop surveys and Biomass Assessment

10.5.1 Comharchumann Sliogéisc Chonamara (Galway) Surveys 2021

Scallop surveys were carried out on the 12-14th October 2021 on the scallop (*Pecten maximus*) beds of Cill Chiaráin Bay, Caisín Bay and Beirtreach Buí. A total of 48 tows were completed in Cill Chiaráin and Caisín Bays using 3 x 0.75 m wide spring-loaded scallop dredges. A total of 35 tows were completed in Beirtreach Buí using a single 1.2 m wide fix-toothed dredge. Scallop catch and bycatch were recorded, weighed and measured on board from each tow. These surveys are a follow-on from surveys previously undertaken by the Marine Institute in these areas in November 2019. The local shellfish co-operative, Comharchumann Sliogéisc Chonamara (CSC), minimum landing size for scallop is 120 mm shell width which is equivalent to 104 mm shell height. Predation of scallops by starfish (*Marthasterias*) in the area is reported by CSC to be high. Biomass of starfish estimated from the surveys is also reported below. The survey dredges use commercial ring sizes and are, therefore, unlikely to select 1 or 2-year-old scallops or to provide evidence of recent recruitment.

10.5.2 Biomass in 2021

Density of all scallops and scallops over 120 mm shell width in Cill Chiaráin Bay, uncorrected for catchability, varied from 0.007-0.03 kgs.m^{-2} and 0.006-0.03 kgs.m^{-2} respectively (Figure 54).

The total biomass of scallops and scallops over 120 mm shell width in the survey area of 2.8 Km^2, uncorrected for catchability, was estimated to be 58 tonnes and 50 tonnes respectively (Table 26). Biomass estimates during the 2019 survey were 76.7 tonnes, but the area surveyed was 1 Km^2 larger than the 2021 survey area. Starfish biomass was estimated to be 8.4 tonnes.

Table 26. Estimates of scallop and starfish biomass (uncorrected for dredge efficiency) in Cill Chiaráin Bay survey area, October 2021.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_*Pecten maximus*	58.0	61.4	50.7	73.1
Biomass_>120mm_*Pecten maximus*	49.9	53.1	43.4	63.2
Biomass_Starfish	8.4	9.6	7	12

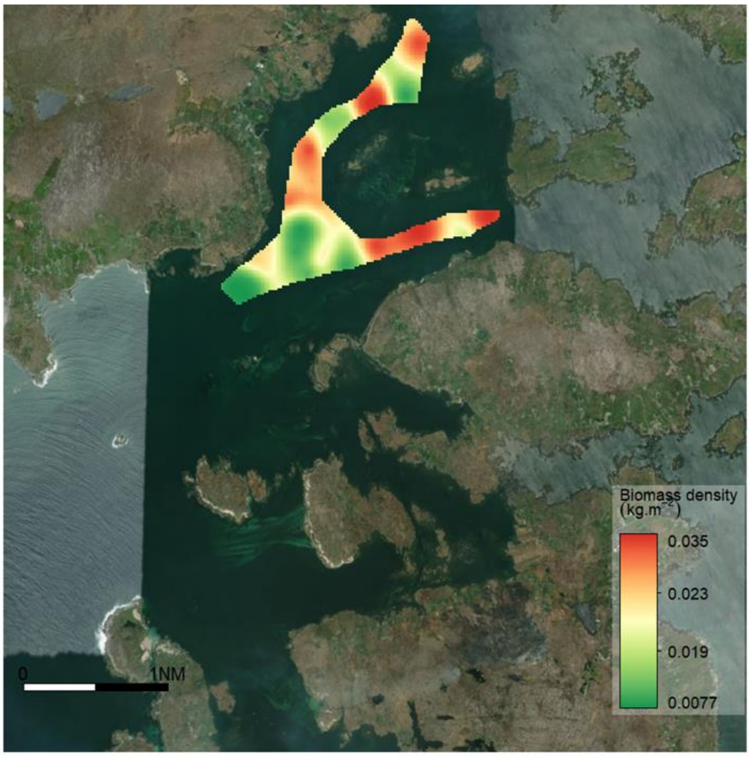

Figure 54. Distribution and biomass of all sizes of scallop (uncorrected for dredge efficiency) in Cill Chiaráin Bay, November 2021.

Density of all scallops and scallops over 120 mm shell width in Caisín Bay, uncorrected for catchability, varied from 0.0003- 0.025 kgs.m^{-2} and 0.0002-0.017 kgs.m^{-2} respectively (Figure 55).

The total biomass of scallops and scallops over 120 mm shell width in the survey area of 0.97 Km^2, uncorrected for catchability, was 8.8 tonnes and 6.1 tonnes, respectively (Table 27). Starfish biomass was estimated to be 7 tonnes.

Table 27. Estimates of scallop and starfish biomass (uncorrected for dredge efficiency) in Caisín Bay survey area, October 2021.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_*Pecten maximus*	8.8	8.8	5.5	13.2
Biomass_>120mm_*Pecten maximus*	6.1	6.1	4.2	8.6
Biomass_Starfish	7.0	6.9	4.9	9.2

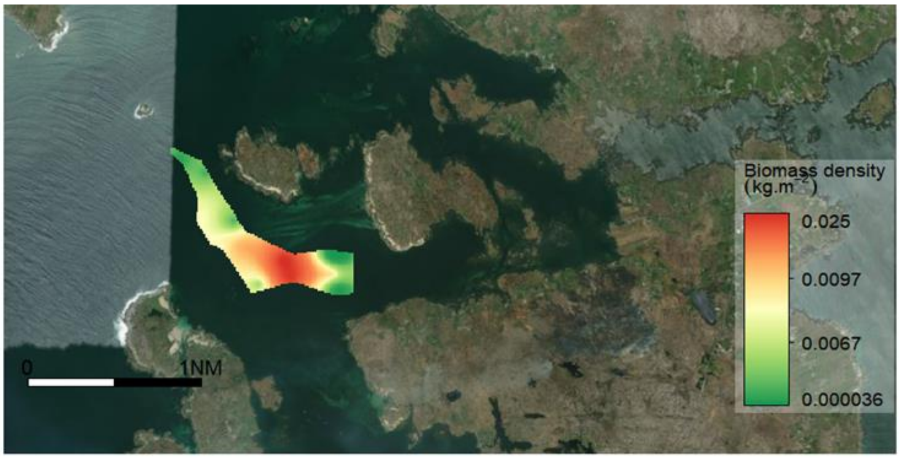

Figure 55. Distribution and biomass of all sizes of scallop (uncorrected for dredge efficiency) in Caisín Bay, October 2021.

Density of all scallops and scallops over 120mm shell width in Beirtreach Buí, uncorrected for dredge efficiency, varied from 0.005-0.017 kgs.m^{-2} and 0.0019-0.0052 kgs.m^{-2} respectively (Figure 56). Densities were higher in the upper bay (Table 28). Starfish biomass was 13.1 tonnes.

Table 28. Estimates of scallop and starfish biomass (uncorrected for dredge efficiency) in Beirtreach Buí Bay survey area, October 2021.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_*Pecten maximus*	6.2	6.2	4.3	8.2
Biomass_>120mm_*Pecten maximus*	4.8	5.2	3.5	6.9
Biomass_Starfish	13.1	14.8	11.7	18

The total biomass of scallops and scallops over 120 mm shell width in the survey area of 1.35 Km^2, uncorrected for catchability, was 6.2 tonnes and 4.8 tonnes, respectively (Table 28). Total biomass reported in 2019 was 7.03 tonnes, but the area surveyed was 0.33 Km^2 larger than in 2021.

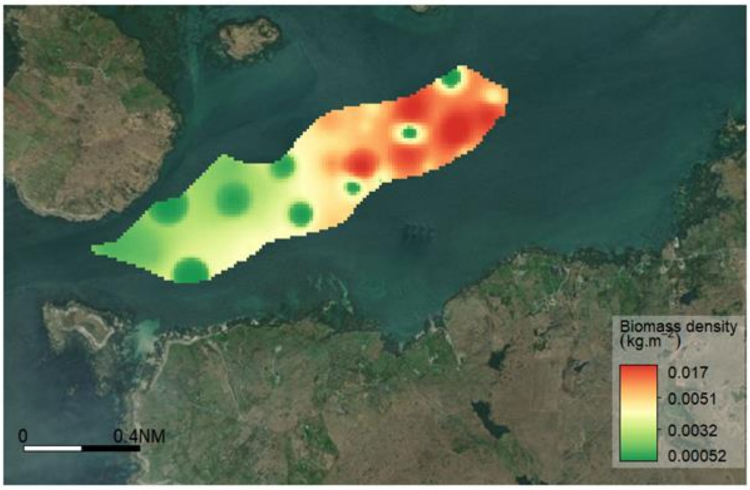

Figure 56. Distribution and biomass of all sizes of scallop (uncorrected for dredge efficiency) in Beirtreach Buí Bay, October 2021.

10.5.3 Size distribution

The size distribution of scallop in Cill Chiaráin Bay showed a strong peak at 110-120 mm shell height (Figure 57), and a smaller mode at 90 mm. Size distributions in 2019 and 2021 surveys were very similar.

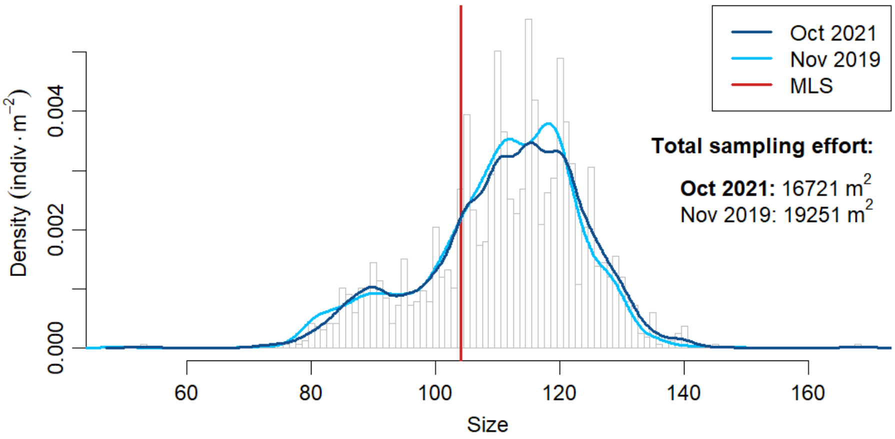

Figure 57. Size distribution and densities of scallop in Cill Chiaráin Bay October 2021. The size data presented here are measurements of scallop shell height (mm). Vertical red line corresponds to the CSC MLS of 120 mm shell width. The size distribution of scallop recorded during the November 2019 survey are included for comparison.

The size of scallops in Caisín Bay in 2021 were slightly larger than recorded in 2019 with a mode just above the MLS (Figure 58).

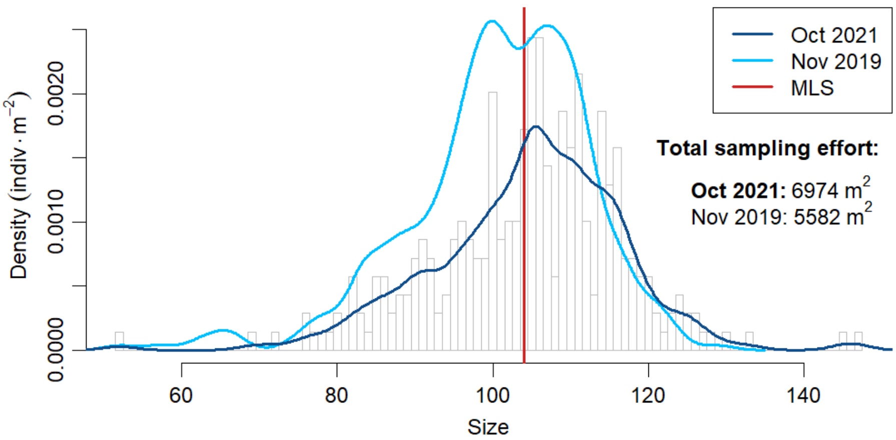

Figure 58. Size distribution and densities of scallop in Caisín Bay October 2021. The size data presented here are measurements of scallop shell height (mm). Vertical red line corresponds to the CSC MLS of 120 mm shell width. The size distribution of scallop from the November 2019 survey in Caisín Bay is included for comparison.

The size distribution of scallop in Beirtreach Buí showed a mode at 110-120mm shell height (Figure 59). Size distributions are similar to those recorded during the 2019 survey.

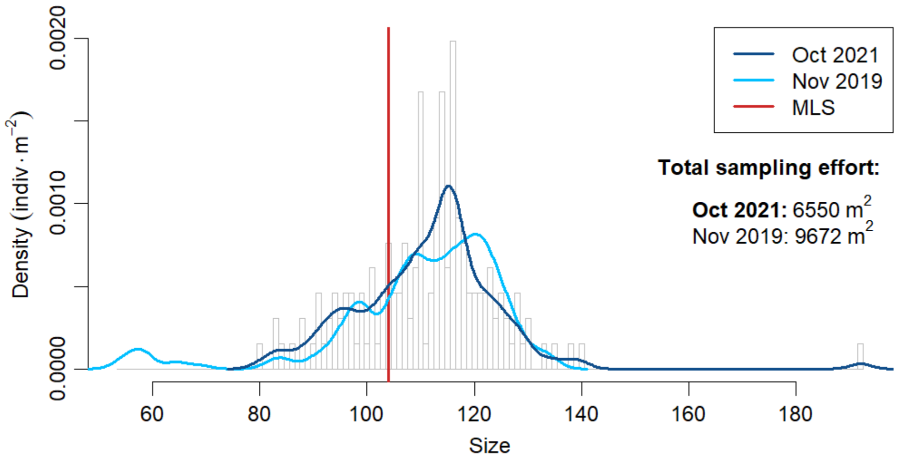

Figure 59. Size distribution and densities of scallop in Beirtreach Buí October 2021. The size data presented here are measurements of scallop shell height (mm). Vertical red line corresponds to the CSC MLS of 120 mm shell width. The size distribution of scallop from the November 2019 survey in Beirtreach Buí is included for comparison.

11 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, e.g. metric tonne, of a stock at a given time.

Bi-valve A filter feeding mollusc with two shells e.g. scallops, cockles.

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

Cultch Shell material deposited on the seabed to provide settlement surface for oyster larvae.

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

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