Shellfish Stocks and Fisheries Review **2023**

BIM Ireland's Seafood Development Agency

Foras na Mara
Marine Institute

Shellfish Stocks and Fisheries

Review 2023

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 and Aquaculture Fund as part of the EMFAF Operational Programme for 2021-2027.

Arna chomhchistiú ag an Aontas Eorpach

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Photographs on cover by Marine Institute Baited Remote Underwater Video camera (Spider crab – Maja brachydactyla) and (Crayfish – Palinurus elephas) and Jonathan White (Whelk – Buccinum undatum) and (Dahlia anemone – Urticina felina)

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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*) 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 (RSW) 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 2023, was 62,296 gross tonnes (GTs) and 1,967 vessels. The polyvalent general segment included 26,323 GTs and 1,373 vessels. The polyvalent potting segment had 320 registered vessels and 666 GTs while the bivalve (specific) segment, including scallop vessels, had 2,274 GTs and 143 vessels. There were 9 beam trawl vessels, 9 scallop vessels over 10 m in the specific segment and 23 RSW pelagic vessels (Table 1).

In 2023 76 % 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 2023.

Segment	U10m	10-12m	12-15m	15-18m	O18m	Total
Aquaculture	74	7	1	1	16	99
RSW Pelagic					23	23
Specific [Scallops >=10m LOA]		1	1		7	9
Beam Trawler					9	9
Polyvalent [Scallops >=10m LOA]		2	1			3
Polyvalent [>=18m LOA]					104	104
Polyvalent [Potting]	302	18				320
Polyvalent [<18m LOA]	1,053	140	59	14		1,266
Specific [General]	74	52	6		2	134
Grand Total	**1,503**	**220**	**68**	**15**	**161**	**1,967**

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 13m 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 12 vessels over 10 m in length were registered in scallop specific and polyvalent segments in 2023.

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 vessels into the polyvalent general segment. There were 320 such vessels in 2023 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 2012-2023 (Figure 1, Table 2 and Table 3).

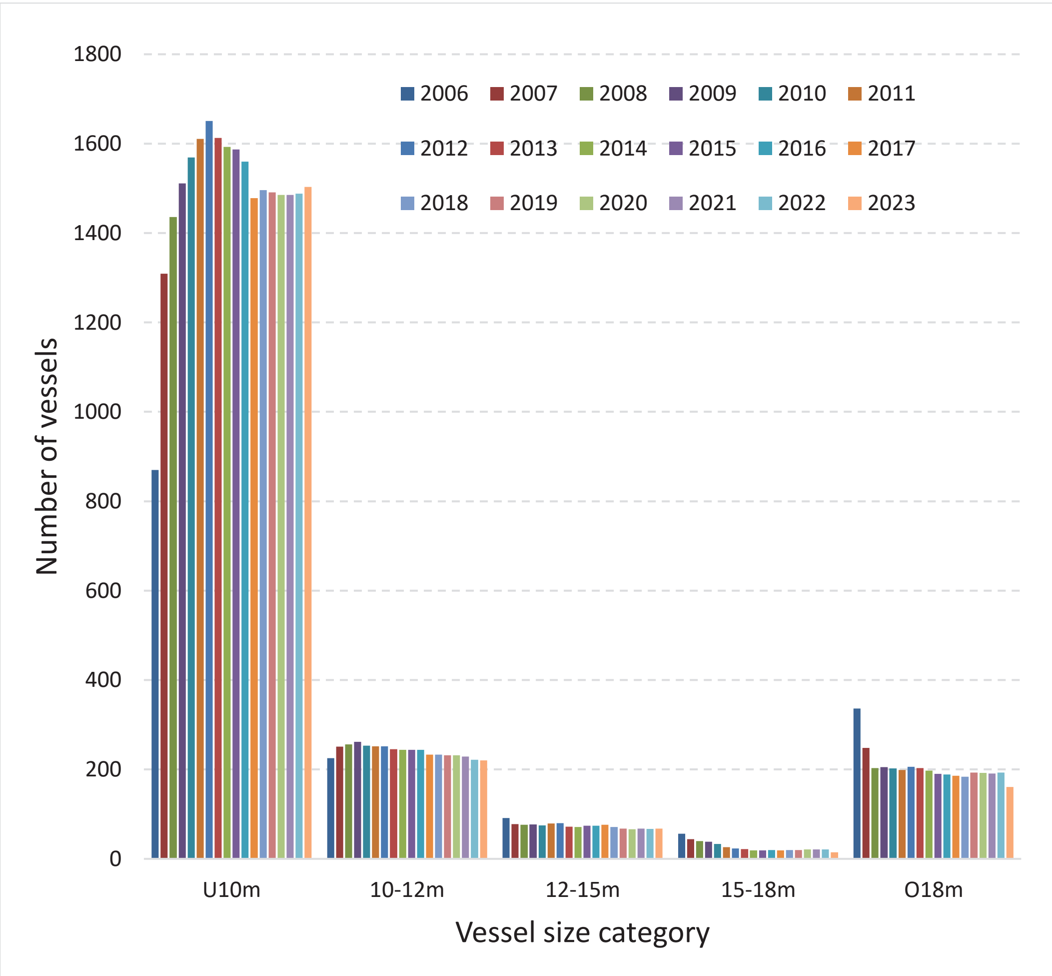


Figure 1. Annual trends in the number of registered sea fishing vessels by length category 2006-2023.

Table 2. Number of vessels and length of vessels in the Irish shellfish fleet 2006-2023 (<13 m polyvalent, all polyvalent potting, all vessels in specific segment, all aquaculture vessels). Vessels over 18 m fishing for crab and scallop are not included.

Year	Aquaculture	Polyvalent General	Polyvalent Potting	Specific	Total
Number of vessels					
2006	3	953	80	97	1,133
2007	13	999	490	93	1,595
2008	46	1,081	482	115	1,724
2009	60	1,146	474	124	1,804
2010	68	1,198	467	120	1,853
2011	78	1,239	461	118	1,896
2012	85	1,269	460	122	1,936
2013	86	1,233	454	117	1,890
2014	89	1,218	448	112	1,867
2015	89	1,226	426	123	1,864
2016	87	1,218	404	126	1,835
2017	83	1,171	363	125	1,742
2018	84	1,200	337	138	1,759
2019	80	1,204	330	136	1,750
2020	79	1,204	329	127	1,739
2021	80	1,201	330	132	1,743
2022	81	1,203	326	127	1,737
2023	81	1,223	320	128	1,753

Table 3. Annual change and percentage change in the numbers of vessels per fleet segment in the under 13 m Shellfish fleet 2006-2023.

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
2017-2018	1	29	-26	13	17
2018-2019	-4	4	-7	-2	-9
2019-2020	-1	0	-1	-9	-11
2020-2021	1	-3	1	5	4
2021-2022	1	2	-4	-5	-6
2022-2023	1	20	-6	1	16
% 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
2017-2018	1	2	-7	10	1
2018-2019	-5	0	-2	-1	-1
2019-2020	-1	0	0	-7	-1
2020-2021	1	0	0	4	0
2021-2022	1.3	0.2	-1.2	-3.8	-0.3
2022-2023	1.2	1.7	-1.8	0.8	0.9

3 Shellfish Landings 2004-2023

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 2004-2023, varied from a high of 29,000 tonnes in 2004 to a low of 13,790 in 2009. Landings were approximately 19.6 thousand tonnes in 2023 (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 (molluscs and crustaceans) landings, excluding periwinkle (no data), mussel seed (fished for relay) and *Nephrops*, in 2023 was just under €70 million.

Table 4. Estimates of annual landings (tonnes) and value (€) of crustacean and bivalve shellfish (excl. prawns and mussels) by Irish vessels into Ireland 2004-2023 (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	Whelk	Shrimp	Native oyster	Queen scallop	Velvet crab	Surf clam	Spider crab	Crayfish	Razor clams	Shore crab	Cockle	Total tonnage
2004	13,607	2,413	855	2,600	416	543	110	291	28	182	80	401	266	207	23,193
2005	9,840	1,229	644	4,154	153	94	75	253	0	146	31	404	27	107	17,867
2006	9,597	644	611	2,917	312	233	172	270	5	151	34	507	46	7	16,368
2007	7,669	917	297	2,644	324	291	28	138	14	66	16	339	91	643	13,575
2008	7,393	1,217	498	2,097	180	88	4	260	34	148	20	456	72	9	13,254
2009	6,101	2,610	423	2,163	224	327	3	204	26	443	28	229	233	173	13,712
2010	8,382	1,959	470	2,975	134	349	0	342	25	414	30	443	129	5	16,649
2011	6,946	2,612	250	3,174	111	100	0	184	36	303	25	523	74	401	14,682
2012	6,261	2,621	244	3,446	148	100	12	169	16	402	35	465	253	400	14,528
2013	6,339	2,797	367	2,628	172	214	134	366	37	228	34	852	30	374	14,679
2014	7,762	2,597	445	2,180	289	265	80	231	67	137	23	903	50	3	15,358
2015	7,018	2,077	363	5,014	295	153	31	202	49	193	14	1,265	23	0	16,579
2016	9,288	2,237	402	5,822	363	190	201	277	51	161	10	1,127	165	321	20,658
2017	8,763	2,580	415	4,977	281	168	7	313	45	143	10	961	127	442	19,553
2018	7,909	2,301	345	4,638	272	150	4	213	47	119	9	1,041	118	446	17,870
2019	8,218	2,345	488	5,090	430	150	3	253	44	425	30	783	288	595	19,020
2020	6,510	1,940	437	5,302	343		1	240	12	451	15	672	154	1,152	17,126
2021	7,868	2,739	628	5,772	342	250	0	328	0	536	49	759	391	642	17,807
2022	7,383	2,252	612	6,329	300	150	823	305	27	560	73	775	640	0	19,093
2023	7,893	2,470	601	5,021	222	309	3	287	26	423	69	801	658	867	19,650
Unit price 2023	€2.99	€3.78	€19.70	€1.57	€19.09	€5.50	€0.80	€2.58	€5.04	€0.58	€33.40	€6.22	€0.49	€2.00	
Value 2023 (million)	€23.60	€9.30	€11.80	€7.88	€4.23	€1.70	€0.0024	€0.74	€0.13	€0.24	€2.30	€4.98	€0.32	€1.73	€68.96

4 Lobster (*Homarus gammarus*)

4.1 *Management*

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 during 2002-2008, 10,000-15,000 during 2010-2013, 25,000-40,000 annually during 2014-2022 and 37,000 in 2023. The MLS, MaxLS and v-notch conservation measure collectively conserve 25-39 % of the reproductive potential (RP) in the lobster population. This varies regionally and by year. In 2022 39 % of the RP was protected by the conservation measures according to data from the pot fishery.

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 2013-2022 in most coastal areas. The index of undersized lobsters increased from 2015-2019 and was stable in 2019-2022.

By-catch of species in the lobster and crab fishery includes a range of invertebrate and fish species. Dogfishes, wrasse and conger eel are the main fish by-catch. Overall the by-catch rate is numerically 0.23% of the targeted crustacean catch.

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 or lobsters above 127 mm is 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 the various sampling programmes.

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 in terms of number of vessels involved and the high unit value of lobsters.

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 and work is ongoing to produce a growth model from these data. Size at maturity has been estimated a number of times; size at 50% maturity is above the minimum landings size.

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 insufficient protection of spawning potential 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. Numbers increased from 2020 to record highs of 27.74 tonnes and 40,000 lobsters in 2022 (Figure 2). The average size at release was approximately 0.7 kg in the period 2020-2023.

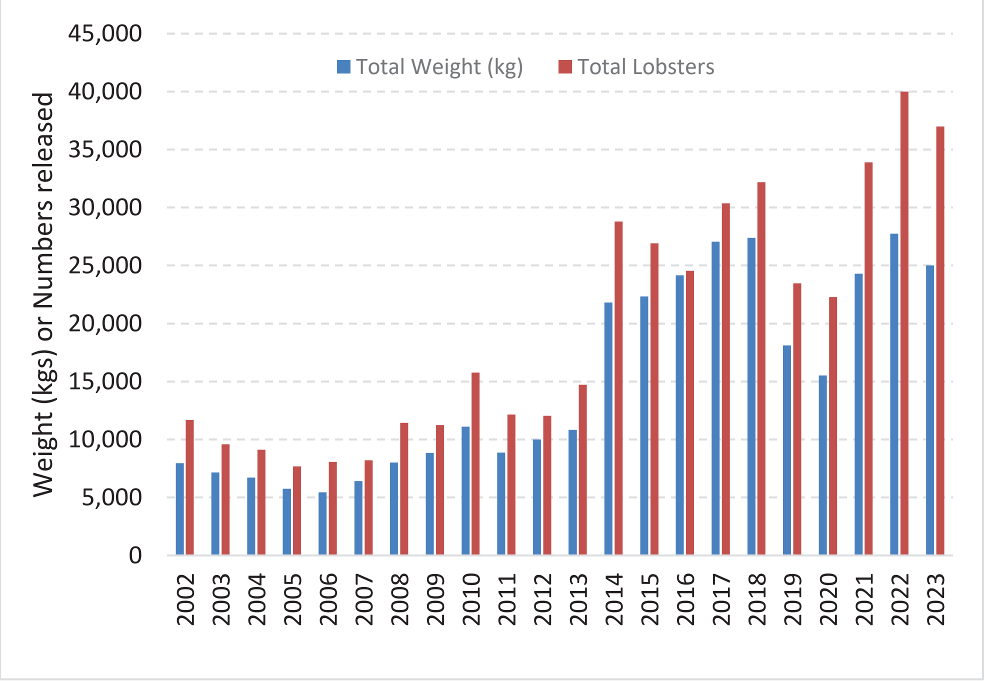


Figure 2. Total number and weight of V-Notched lobsters releases 2002-2023.

4.6 *Reproductive potential (pot data)*

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 2022 observer data showed that lobsters below 87 mm accounted for 23.2 % of RP, lobsters in the fishable size range accounted for 61 % of RP, v-notched lobsters in that size range accounted for 11.9 % of RP and the remainder of RP was in lobsters over 127 mm (2.3 % in v-notched lobsters over 127 mm and 1.37 % in lobsters over 127 mm that are not v-notched). In 2022, the contribution of v-notched lobsters both in the 87-127 mm size range and above the 127 mm maximum size limit are substantially smaller than in 2021. Observer data in 2021 was less comprehensive than the rest of the time series, but 2022 data is an exception to the increasing trends in numbers of V-notched lobsters observed from 2017 onwards. Data in 2022, also shows the highest RP contribution in lobsters below the 87mm MLS of the time series. The variability shown in these figures might reflect changes in both the amount and spatial variability of sampling. The data from the Skipper self-sampling programme, established in 2021, have yet to be incorporated into these figures.

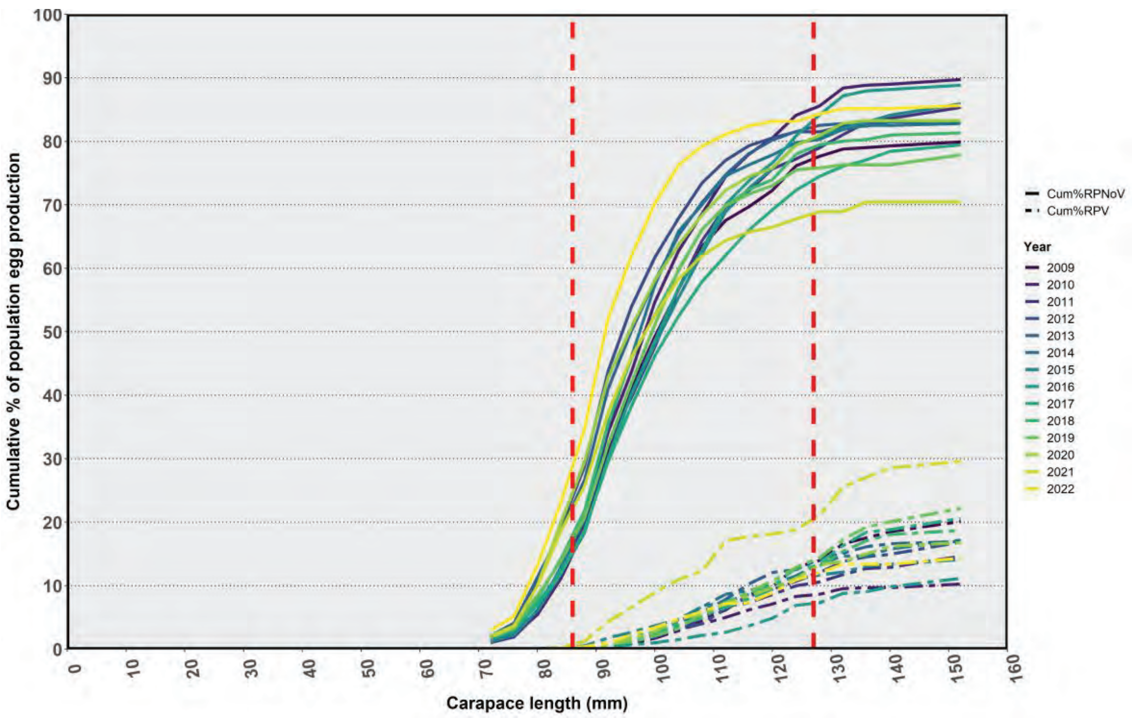


Figure 3. Cumulative distribution of reproductive potential (RP) across size classes of V-notched and non-V-notched lobsters for all regions combined. Source: Marine Institute Observer data 2009-2022.

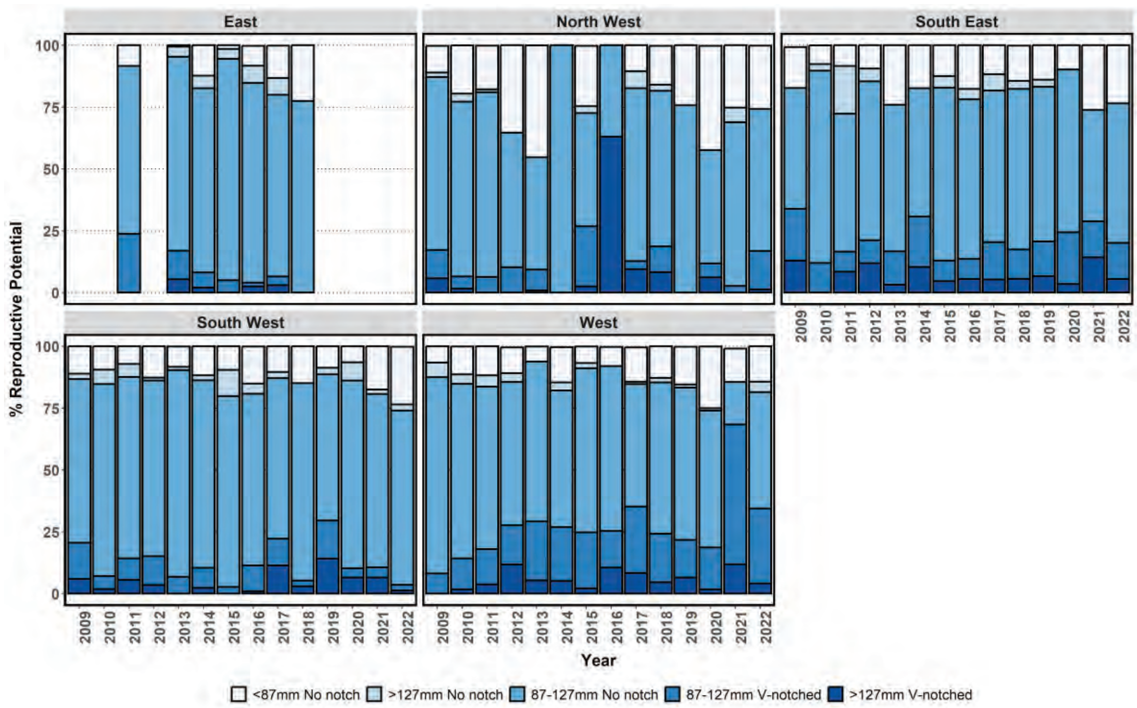


Figure 4. Summary of the distribution of the % reproductive potential in lobster stocks conserved by v-notching, minimum size and maximum size measures by region. Marine Institute Observer data 2010-2022.

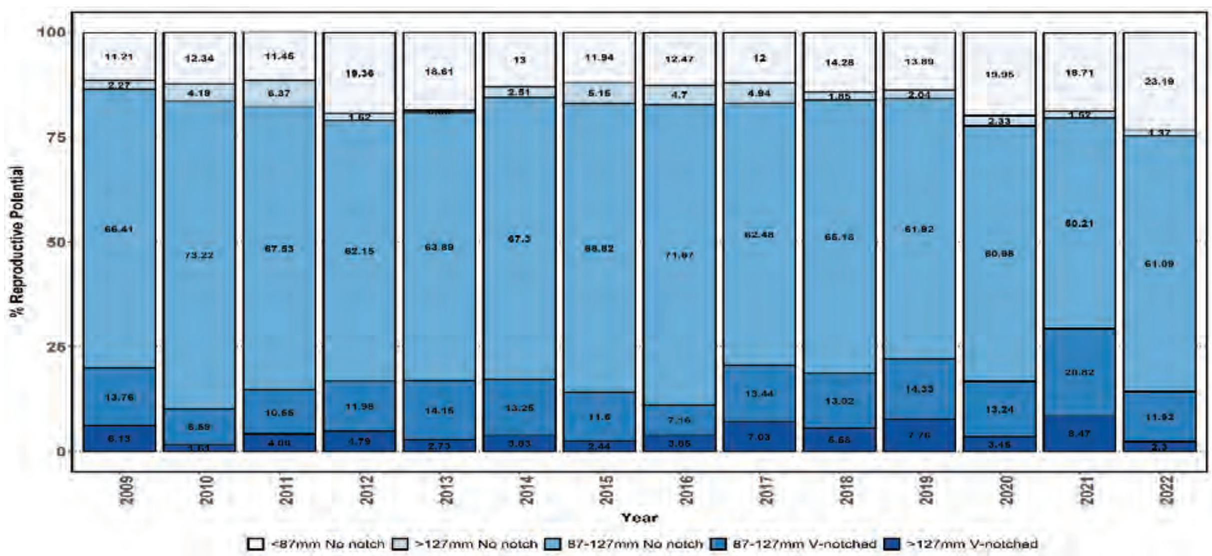


Figure 5. Summary of the distribution of the % reproductive potential in lobster stocks conserved by v-notching, minimum size and maximum size measures for all regions combined. Source: Marine Institute Observer data 2010-2022.

4.7 *Catch rates*

This report includes the SVP data from 2013-2022, the MI observer data from 2014-2022, and for the first time, the skipper-self-sampling data 2021-2022. 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 mean or modal size of lobsters reported in the observer data. A length-weight relationship from port-processor data was applied ($\mathbf{W}=1.42*10^{-6}\mathbf{L}^{2.84}$) where W is weight and L is carapace length.

The catch rates of legal sized (LPUE) lobsters and undersized discarded (DPUE) lobsters from 2013-2022, all areas combined, were stable without any clear trends (Figure 6, Figure 7). Skipper-self-sampling data is comparable in terms of scale and trends to the SVP and observer datasets, with annual mean LPUE and DPUE values within the range of the more established data collection programmes. Observer data generally reports higher catch rates, especially for the discarded component of the catch. 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.

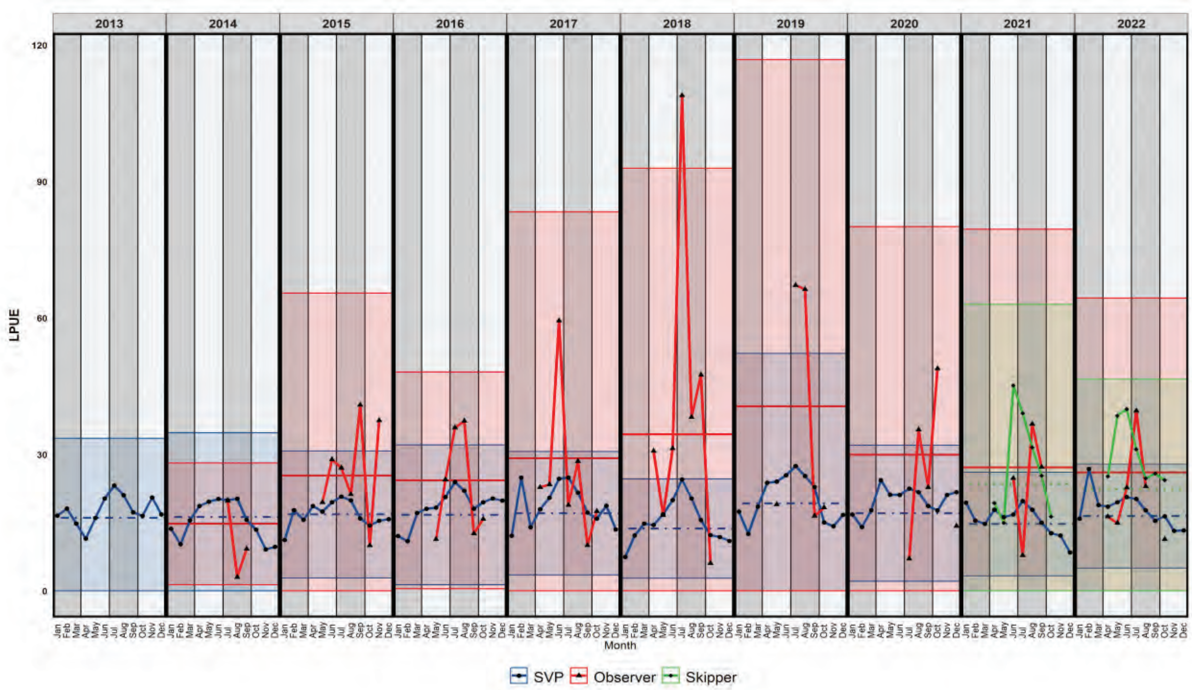


Figure 6. Annual mean landings of lobster per effort (LPUE per 100 Pots) for the SVP (2013-2022), MI Observer programme (2014-2022) and Skipper self-sampling programme in 2021 and 2022.

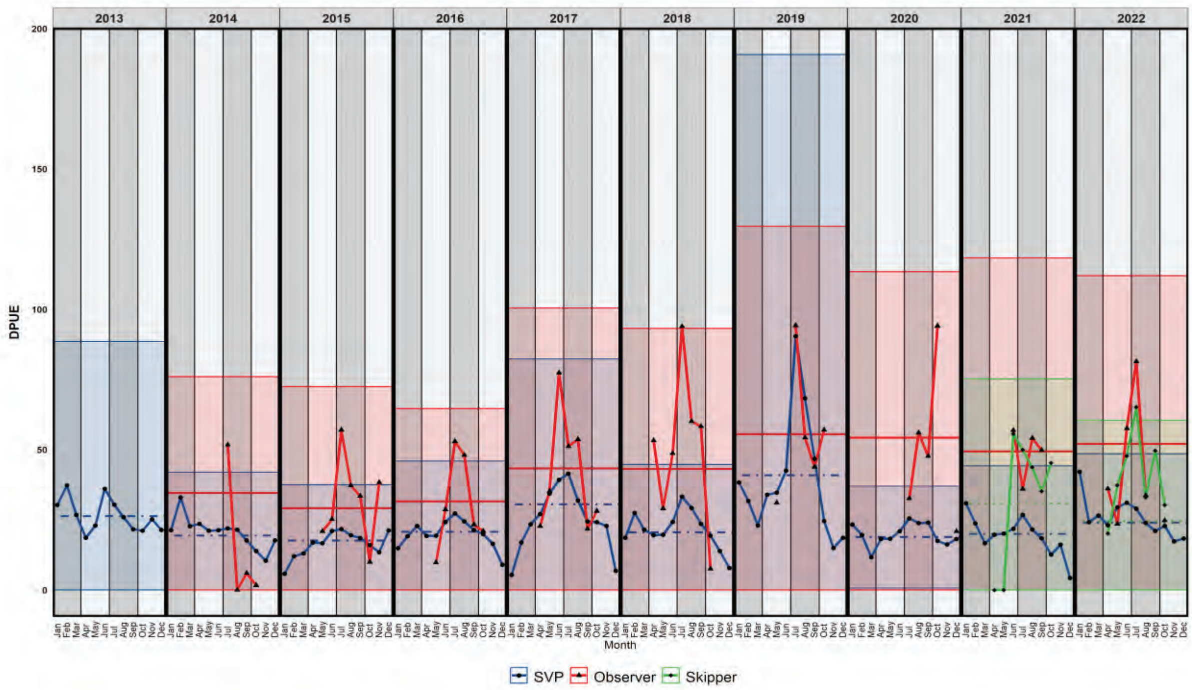


Figure 7. Annual mean discards of lobster per effort (DPUE per 100 Pots) for the SVP (2013-2022) and MI Observer programme (2014-2022) and Skipper self-sampling programme in 2021 and 2022.

4.8 *Size composition*

4.8.1 Pots

The annual size composition data of discarded and landed lobsters in pots used to target lobster is stable (Figure 8). The number of lobsters measured in the observer programme has declined in recent years but this has been augmented by a Skipper sampling programme since 2021 (Figure 9).

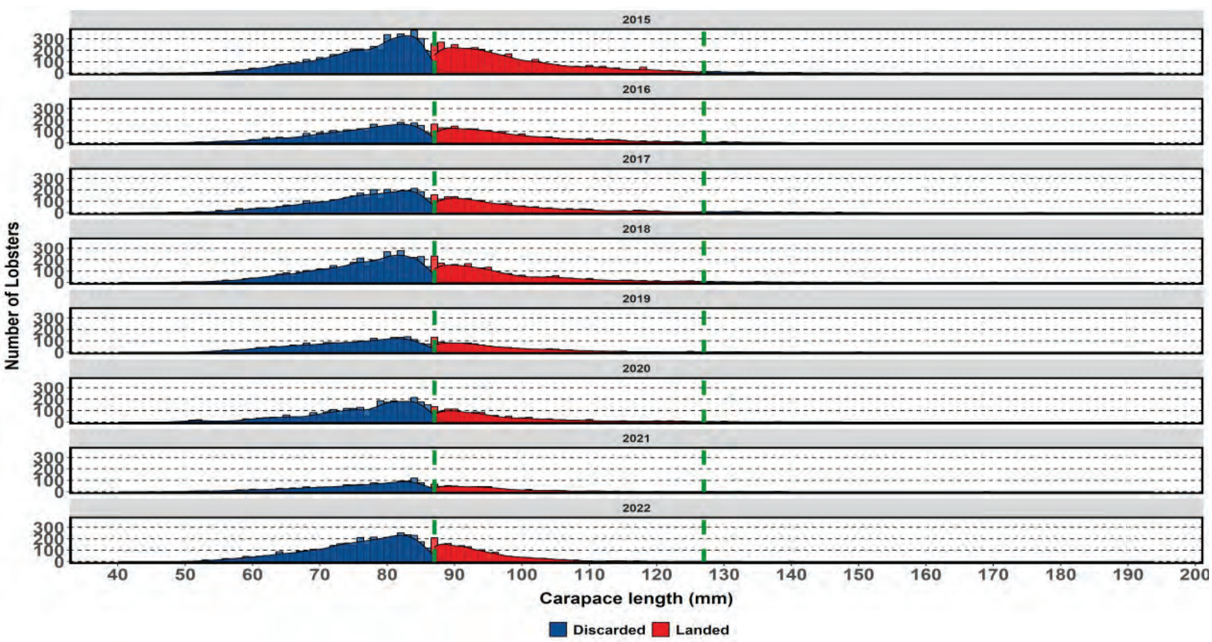


Figure 8. Annual size distributions of discarded (<87 mm, >127 mm) and landed lobsters across all regions. Marine Institute observer data 2015-2022.

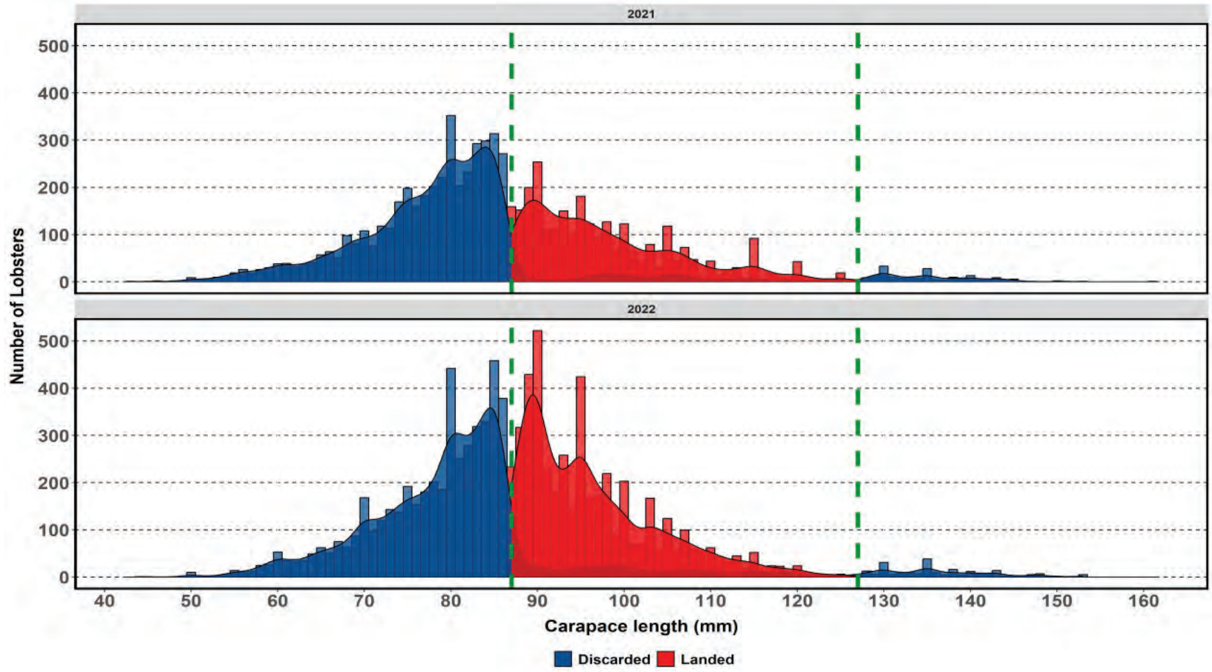


Figure 9. Annual size distributions of discarded (<87 mm, >127 mm) and landed lobsters across all regions. Marine Institute Skipper self-sampling data 2021-2022.

4.9 *By-catch in the lobster and crab fishery*

Pot or trap fisheries for lobster and crab are generally regarded as low impact fisheries with respect to their effects on habitats and non-target species. Nevertheless, by-catch does occur and given that the number of pot hauls in lobster and crab fisheries is in the millions per annum there are potential effects on sensitive species or species of conservation concern if these are commonly caught as by-catch. The species composition and diversity in the by-catch is expected to be different in crab and lobster pot fisheries because they occur on different habitats; lobster fishing occurs or reef or rough ground while crab fishing, especially for female crab, occurs on mixed sedimentary habitats.

The MI observer programme records the species of by-catch in fishing trips targeting lobster and crab. The intended or targeted catch in these fishing trips is European lobster or edible crab but commercial species such as velvet crab, spider crab and green crab may also be caught depending on location of fishing. The fishing gear used in these trips is primarily soft-eye side entrance creels. Targeted and by-catch composition may be different in other pots such as hard eye top entrance pots. In the analysis presented here these commercial crustacean species are regarded as intended catch and all other species are regarded as by-catch. Although commercial spiny lobster and whelk and some finfish are caught their numbers are very low in soft eye pots. The annual observed fishing effort varied from 10,000-30,000 pot hauls (Figure 10).

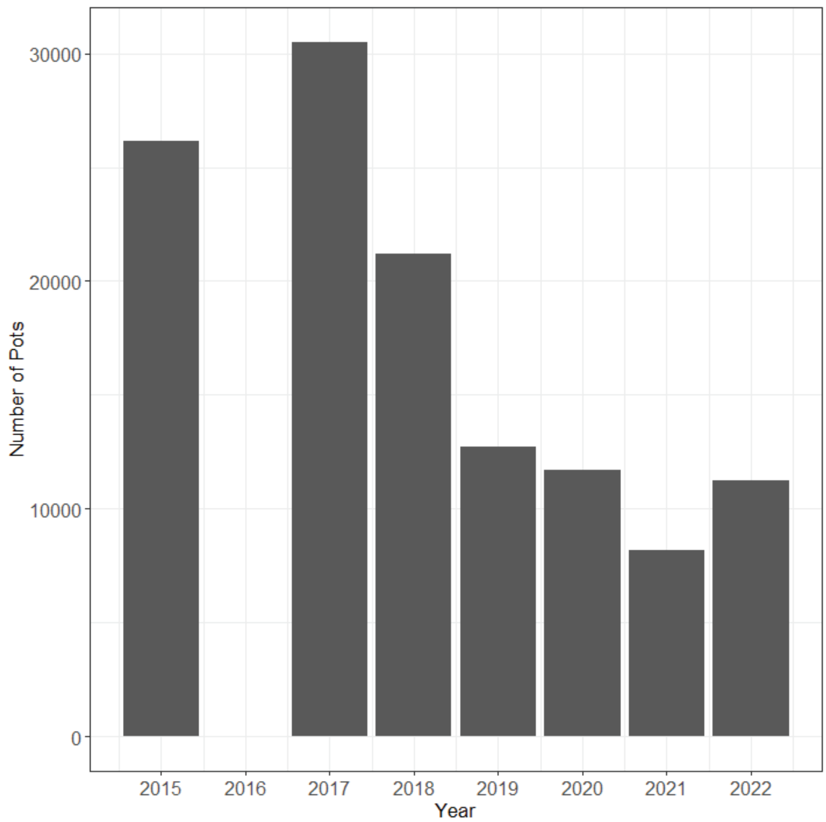


Figure 10: Annual observed pot hauls for estimation of by-catch in the lobster and crab fishery.

The targeted catch in the observer trips for years 2014-2022 combined was dominated numerically (96 %) by edible crab and then by lobster and other commercial species of crab (Table 5, Figure 11, Figure 12). Total by-catch of all other species is 0.23 % of the total commercial crustacean catch. Numerically starfish/urchins/sea cucumber, whelk, dogfish, conger eel and various species of wrasse were the dominant bycatch species.

A non-metric multidimensional scaling plot shows that lobster and crab trips are different with respect to total species catch composition (Figure 13) but this difference is mainly due to the targeting intention and the relative numbers of crab and lobster in the resulting catch (Figure 14). The by-catch species composition is quite similar across pots targeting crab and those targeting lobster. This is unexpected given the different types of ground used by crab (female crab at least) and lobster. However, the degree of targeting of lobster or crab varies; the target intention may be one or the other but the catch is usually of both. There is an overlap in habitat distribution in inshore lobster and crab grounds. All the data comes from coastal waters and not offshore crab ground where the by-catch species composition may be different.

Table 5. Observed species composition in pot fisheries targeting lobster and crab in Irish inshore waters 2015-2022.

Code	Species name	Number	%
Total commercial crustaceans			
CRE	EDIBLE CRAB	2,135,153	95.98
LBE	EUROPEAN LOBSTER	43,341	1.95
MLP	VELVET SWIMMING CRAB	26,921	1.21
SCR	SPIDER CRAB	10,694	0.48
CRG	GREEN SHORE CRAB	8,332	0.37
SLO	COMMON SPINY LOBSTER	39	0.0018
	Total number caught	**2,224,480**	
By-catch			
API	STARFISH/SEA URCHNS/CUCUMBERS	1,208	23.511
WHE	COMMON WHELK	1,206	23.472
LSD	LESSER SPOTTED DOGFISH	778	15.149
COE	EUROPEAN CONGER EEL	284	5.531
BNW	BALLAN WRASSE	256	4.982
WRA	WRASSES	255	4.963
PAY	HERMIT CRABS	195	3.795
DGZ	SQUALID SHARKS	116	2.258
CUW	CUCKOO WRASSE	114	2.219
WHG	WHITING	108	2.102
DGN	NURSE HOUND	90	1.752
COD	COD	81	1.576
DAB	DAB	64	1.246
TBR	THREE-BEARDED ROCKLING	64	1.236
HAD	HADDOCK	36	0.701
OCV	COMMON OCTOPUS	35	0.681
BIB	WHITING-POUT (BIB)	35	0.681
LIN	COMMON LING	26	0.506
POL	POLLACK	21	0.409
MNR	SQUAT LOBSTER	19	0.370
RPG	REDTAIL PORGY	18	0.350
RED	REDFISHES	16	0.311
NOP	NORWAY POUT	11	0.214
	Unidentified	11	0.214
JOD	JOHN DORY	10	0.195
TRF	TRIGGER FISH	10	0.195
DGH	DOGFISHES	9	0.175
ROL	ROCKLINGS	6	0.117
SMW	SMALL-MOUTHED WRASSE	6	0.117
EDC	CURLED OCTOPUS	5	0.097
FVR	FIVE-BEARDED ROCKLING	5	0.097
MUR	RED MULLET	5	0.097
SOL	BLACK SOLE	4	0.078
GFB	GREATER FORKBEARD	4	0.078
POD	POOR COD	4	0.078
JAX	JACK-MACKERELS	3	0.058
LEM	LEMON SOLE	3	0.058
POG	POGGE (ARMED BULLHEAD)	3	0.058
POK	SAITHE	3	0.058
PLE	PLAICE	2	0.039
LMD	SWIMMING CRAB	2	0.039
LMA	ARCH-FRONT SWIMMING CRAB	1	0.019
BNX	BLENNIES	1	0.019
RBM	BLUE-MOUTH REDFISH	1	0.019
NNU	COMMON NUT SHELL	1	0.019
MON	MONKFISH	1	0.019
CPZ	SQUIDS OCTOPUSSES ETC.	1	0.019
TKT	TOPKNOT	1	0.019
	Total by-catch by number	**5,138**	

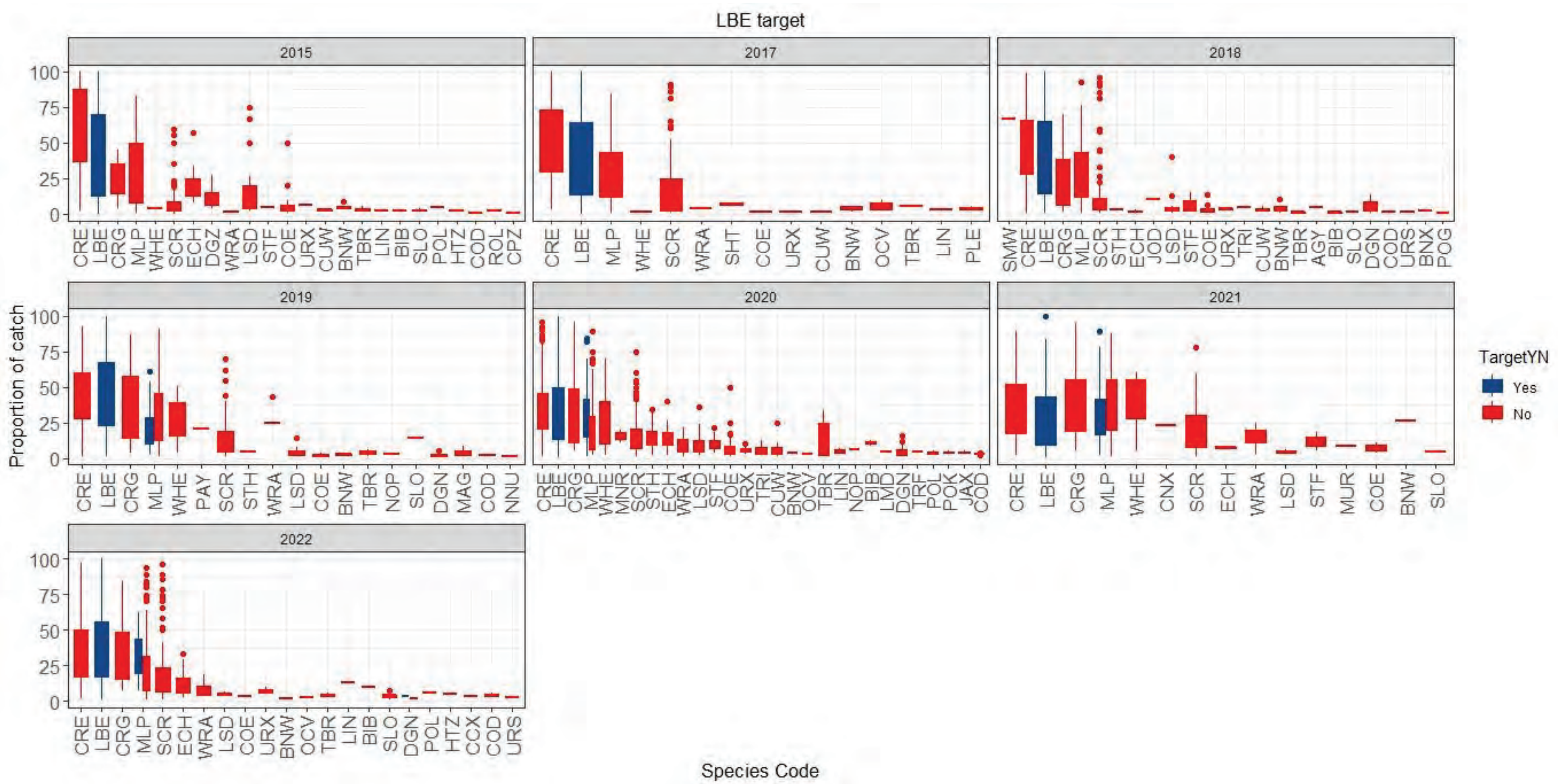


Figure 11. Annual observed species catch composition in pot fisheries targeting lobster. Bycatch was not recorded in 2014 or 2016. The common names for the species codes are in Table 5.

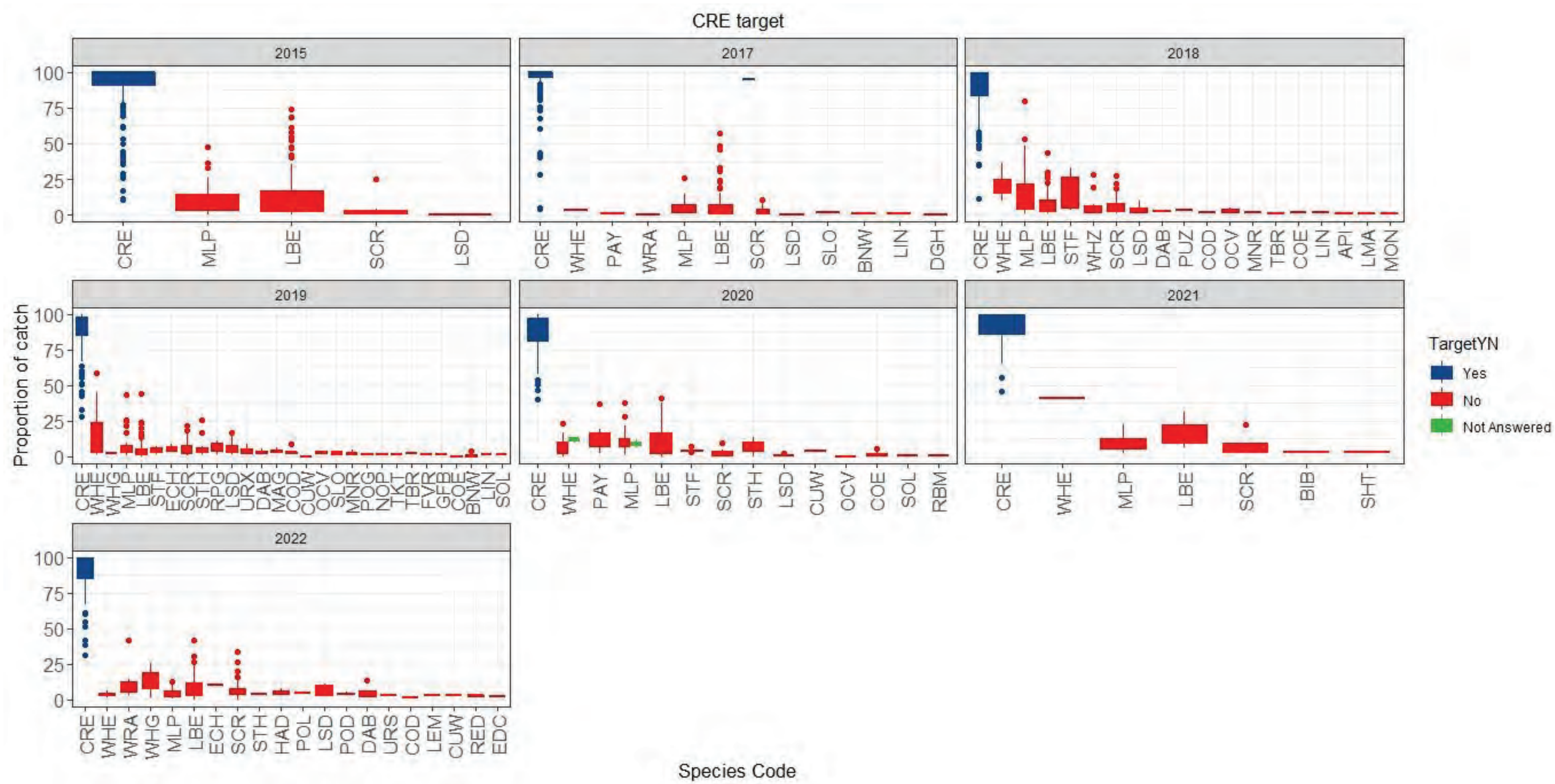


Figure 12. Annual observed species catch composition in pot fisheries targeting crab. Bycatch was not recorded in 2014 or 2016. The common names for the species codes are in Table 5.

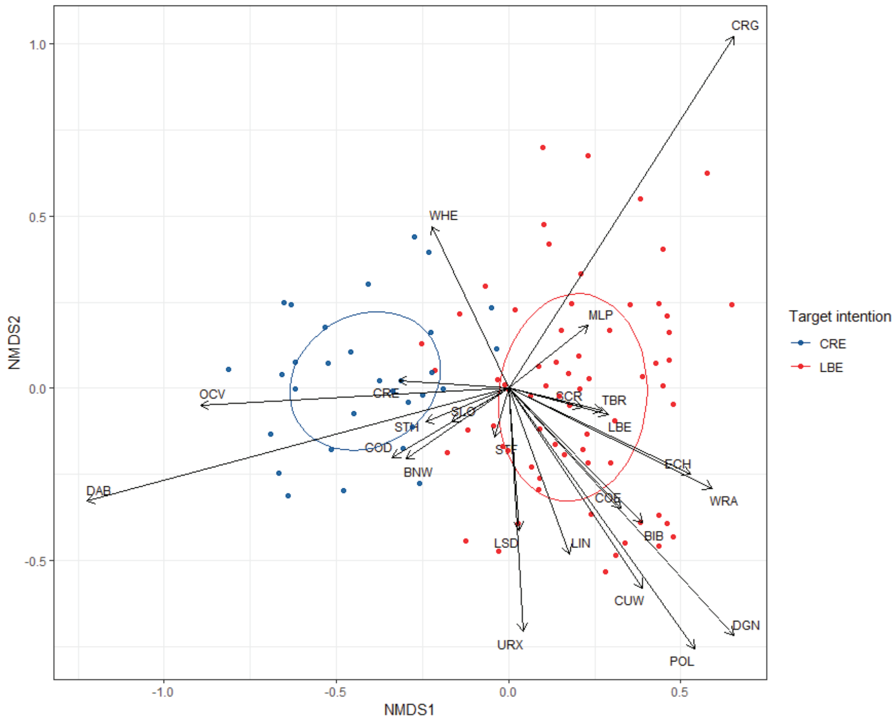


Figure 13. Non-metric multidimensional scaling plot representing the dissimilarity of species catch composition (all species) in pots targeting lobster (LBE) and pots targeting crab (CRE).

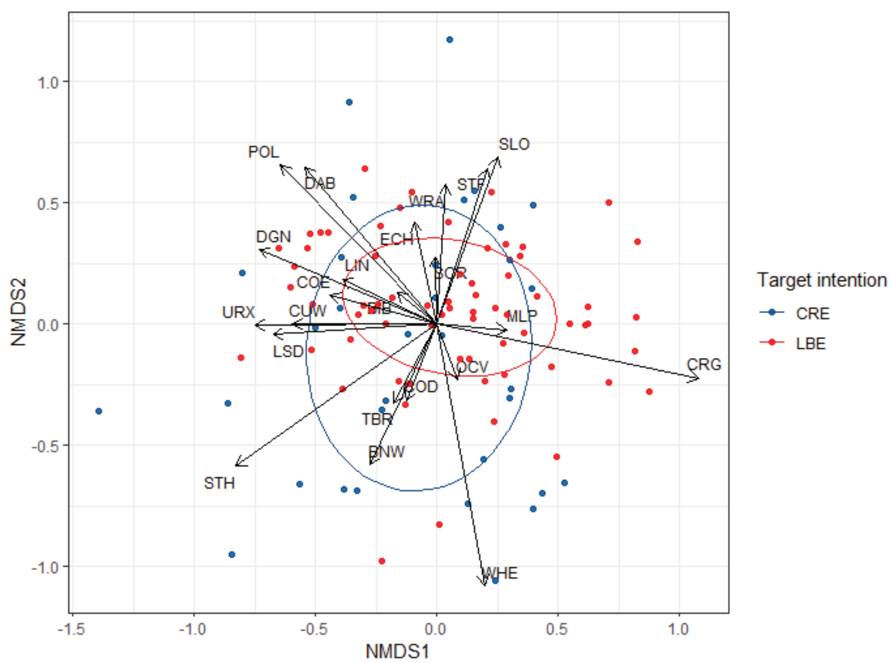


Figure 14. Non-metric multidimensional scaling plot representing the dissimilarity of species catch composition (excluding commercial species of lobster and crab) in pots targeting lobster (LBE) and pots targeting crab (CRE).

5 Crayfish (*Palinurus elephas*)

5.1 *Management advice*

Crayfish are fished with large mesh tangle nets. The fishery is 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 tangle 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. Tagging data suggests a high level of residency of commercial sized crayfish on reef habitat in coastal waters.

Spider crab, crayfish, brown crab and lobster are the most common commercial species in the tangle net catch. Catches of crayfish vary seasonally and are usually between 10-20 fish per nautical mile (nm) of net hauled. Annual average catch rates increased from approximately 5 to 20 fish per nm of net between 2017 and 2021 and declined slightly in 2022-2023. Unit value is 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 the tangle net fishery. The fishery off the south west coast in particular overlaps with an area of high diversity of elasmobranch fish (skates and rays) and is close to grey seal haul outs and areas designated for harbour porpoise. Twelve species of elasmobranch fish 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 seal population, at the Blasket Islands. Dolphin by-catch is rare.

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 by-catch and 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 (2017-2023) 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 and Cornwall indicates limited movement of adult crayfish and 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 tangle nets*

Species catch composition and catch rates have been estimated from observer and skipper sampling data between 2017-2023. Between 300 and 800 nm of net hauls have been observed annually.

Table 6. Species catch composition in tangle nets targeting crayfish off the south west coast of Ireland 2017-2023. Data are total numbers caught in each year by all boats in the sampling programme. Broader geographic areas were sampled in 2021-2023 and more vessels were involved. Two Angle shark recaptures were reported.

Species	2017	2018	2019	2020	2021	2022	2023	Total
Spider Crab (*Maja brachydactyla*)	3,294	7,320	7,369	3,931	6,538	8,411	10,363	**47,226**
Crayfish (*Palinurus elephas*)	3,992	4,147	3,328	3,893	7,836	10,663	13,347	**47,206**
Brown Crab (*Cancer pagurus*)	3,548	7,034	3,783	3,360	5,353	6,304	7,551	**36,933**
Lobster (*Homarus gammarus*)	500	785	658	757	561	777	883	**4,921**
Pollack (*Pollachius pollachius*)	11	185	203	65	386	876	961	**2,687**
Monkfish (*Lophius spp*)	38	89	79	72	246	359	476	**1,359**
Turbot (*Scophthalmus maximus*)	37	58	87	133	100	207	277	**899**
Black Pollack (*Pollachius virens*)	0	0	0	0	2	25	0	**27**
Spurdog (*Squalus acanthias*)	49	155	1,115	583	1,861	2,162	2,575	**8,500**
Thornback (*Raja clavata*)	52	87	165	117	277	532	784	**2,014**
Dog fish (*Scyliorhinus spp*)	37	6	1	10	563	606	792	**2,015**
Spotted Ray (*Raja montagui*)	0	11	22	59	196	298	143	**729**
Grey Seal (*Halichoerus grypus*)	8	45	73	74	55	141	93	**489**
Blonde Ray (*Raja brachyura*)	0	22	5	0	74	208	298	**607**
Common/Flapper Skate (*Dipturus spp*)	0	8	12	0	117	172	121	**430**
Unidentified Skate	70	26	1	5	0	0	0	**102**
Painted Ray (*Raja microocellata*)	0	5	0	4	54	16	40	**119**
Sting Ray (*Dasyatis pastinaca*)	0	1	0	2	24	27	30	**84**
Angel Shark (*Squatina squatina*)	0	0	2	1	0	16	2	**21**
Undulate Ray (*Raja undulata*)	0	1	0	0	3	12	0	**16**
Longnose skate	0	0	0	0	0	0	3	**3**
Cuckoo Ray (*Leucoraja naevus*)	0	0	2	0	0	0	0	**2**
White Skate	0	1	0	0	0	0	0	**1**
Harbour porpoise	0	0	0	0	0	1	0	**1**
Common dolphin	0	0	0	0	0	0	1	**1**
Risso's dolphin	0	0	0	0	0	1	0	**1**
Total	**11,636**	**19,986**	**16,905**	**13,066**	**24,246**	**31,814**	**38,740**	**156,393**

In 2023 crayfish were, numerically, the most common species caught in tangle nets off the Kerry coast followed by spider crab and brown crab. 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 6 and Table 7).

Table 7. Species catch composition in tangle nets targeting crayfish off the south west coast of Ireland 2017-2023 standardised to 100 nm of net hauls observed.

Species	2017	2018	2019	2020	2021	2022	2023	Total
Spider Crab (*Maja brachydactyla*)	766	1,723	2,346	1,265	1,344	1,260	1,257	**9,961**
Crayfish (*Palinurus elephas*)	928	976	1,060	1,253	1,611	1,597	1,619	**9,044**
Brown Crab (*Cancer pagurus*)	825	1,656	1,205	1,081	1,101	944	916	**7,727**
Lobster (*Homarus gammarus*)	116	185	210	244	115	116	107	**1,093**
Pollack (*Pollachius pollachius*)	3	44	65	21	79	131	117	**459**
Monkfish (*Lophius spp*)	9	21	25	23	51	54	58	**240**
Turbot (*Scophthalmus maximus*)	9	14	28	43	21	31	34	**178**
Black Pollack (*Pollachius virens*)	0	0	0	0	0	4	0	**4**
Spurdog (*Squalus acanthias*)	11	36	355	188	383	324	312	**1,609**
Thornback (*Raja clavata*)	12	20	53	38	57	80	95	**355**
Dog fish (*Scyliorhinus spp*)	9	1	0	3	116	91	96	**316**
Spotted Ray (*Raja montagui*)	0	3	7	19	40	45	17	**131**
Grey Seal (*Halichoerus grypus*)	2	11	23	24	11	21	11	**103**
Blonde Ray (*Raja brachyura*)	0	5	2	0	15	31	36	**89**
Common and Flapper Skate (*Dipturus spp*)	0	2	4	0	24	26	15	**70**
Unidentified Skate	16.27	6.12	0.32	1.61	0	0	0	**24.32**
Painted Ray (*Raja microocellata*)	0	1.18	0	1.29	11.10	2.40	4.85	**20.82**
Sting Ray (*Dasyatis pastinaca*)	0	0.24	0	0.64	4.93	4.04	3.64	**13.50**
Angel Shark (*Squatina squatina*)	0	0	0.64	0.32	0.00	2.40	0.24	**3.60**
Undulate Ray (*Raja undulata*)	0	0.24	0	0	0.62	1.80	0	**2.65**
Longnose skate	0	0	0	0	0	0	0.36	**0.36**
Cuckoo Ray (*Leucoraja naevus*)	0	0	0.64	0	0	0	0	**0.64**
White Skate	0	0.24	0	0	0	0	0	**0.24**
Harbour porpoise	0	0	0	0	0	0.15	0	**0.15**
Common dolphin	0	0	0	0	0	0	0.12	**0.12**
Risso's dolphin	0	0	0	0	0	0.15	0	**0.15**
Total	**2,704**	**4,704**	**5,383**	**4,204**	**4,985**	**4,765**	**4,700**	**31,446**

5.6 *Bycatch of critically endangered and protected species*

A number of critically endangered species including Angel Shark, Skate spp (probably Flapper skate) and protected Grey Seal are caught as by-catch in the tangle net fishery as shown above. Single captures of Risso's dolphin, Harbour Porpoise and Common Dolphin were recorded in the by-catch in 2022 and 2023.

Twenty-one Angel shark have been reported in the tangle net by-catch since 2017. In addition, one was captured on rod and line east of Fenit in 2023 and another was reported outside of the sampling progamme. Most of the captures are north west of Tralee Bay (Figure 15). Not all tangle net fishing effort is monitored and it is not possible to raise the sample by-catch to total by-catch. By-catch peaks in August and September. There is a smaller peak in April (Figure 16). These peaks may reflect times of movement of this species into or out of the Bay. Historically it was abundant in the shallow sandy areas of the inner Bay.

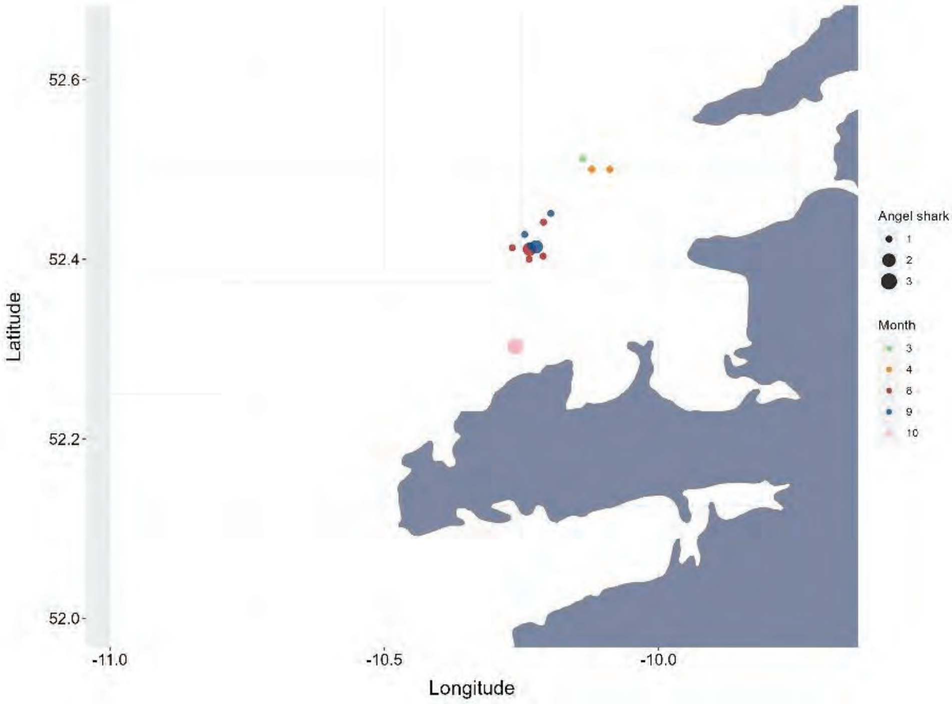


Figure 15. Number and distribution of by-catch of Angel shark in outer Tralee Bay 2017-2023. A total of 23 individuals were captured.

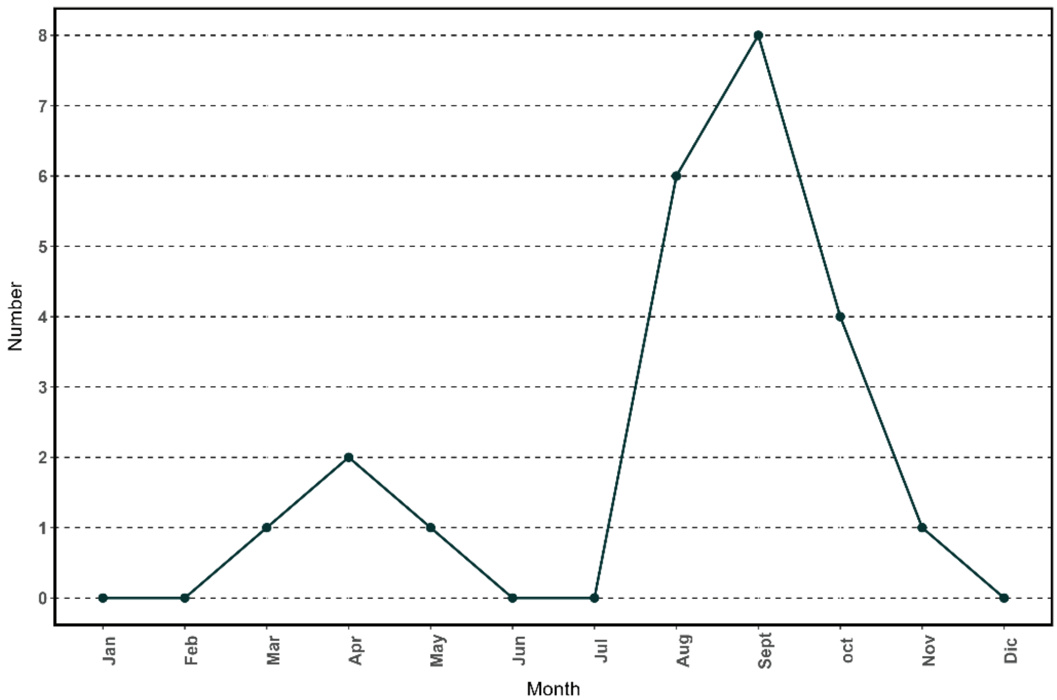


Figure 16. Monthly distribution of by-catch of Angel shark in outer Tralee Bay 2017-2023. A total of 23 individuals were captured.

Skate occurs in the bycatch throughout the area where tangle net fishing occurs from Kerry Head south to the Blaskets and Dingle Bay. By-catch occurs also further south but there is less monitoring in this area (Figure 17). Most captures have occurred in early summer and autumn while catch rate (per 100 nm of net) peak in summer and in early winter (Figure 18).

Grey Seal are captured as by-catch in most of the area used by tangle nets. By-catch rates are, however, higher around the Blasket Islands and within 10 km of the haul out site on the Great Blasket

Islands (Figure 19). Total numbers reported caught by month peaks in April-July. The by-catch per effort peaks in April and declines through to October (Figure 20).

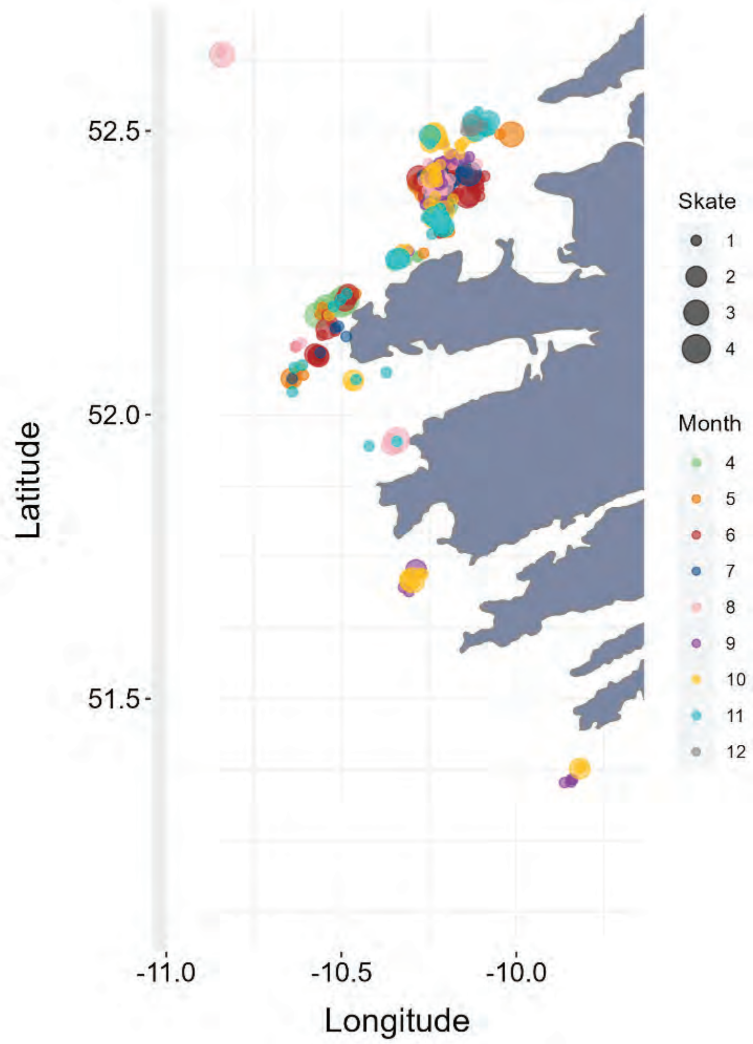


Figure 17. Number and distribution of by-catch of Skate spp. in outer Tralee Bay 2017-2023.

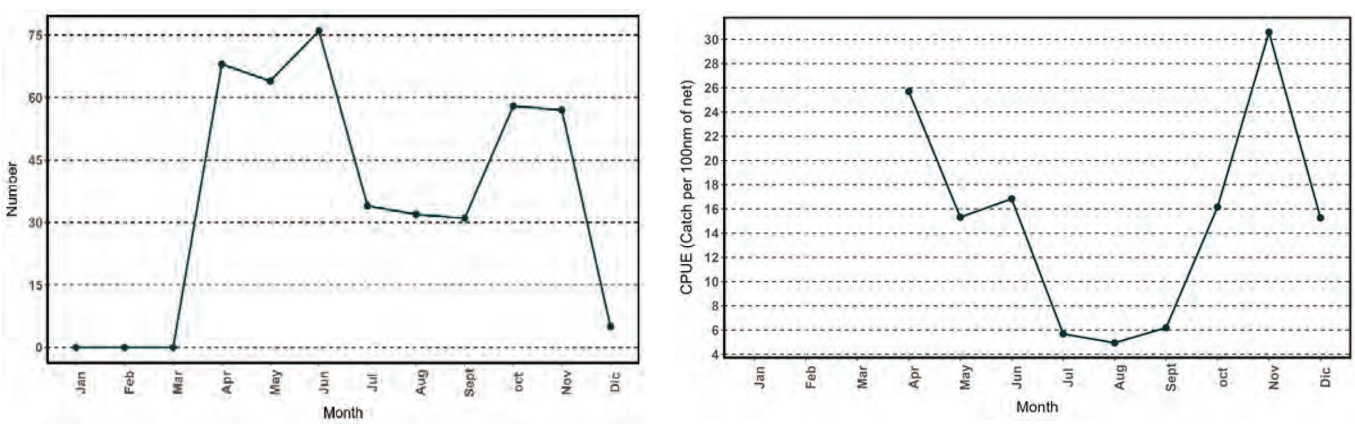


Figure 18. Monthly distribution of by-catch of Skate spp. in outer Tralee Bay 2017-2023. Numbers caught per month (left) and catch per 100nm of effort (right).

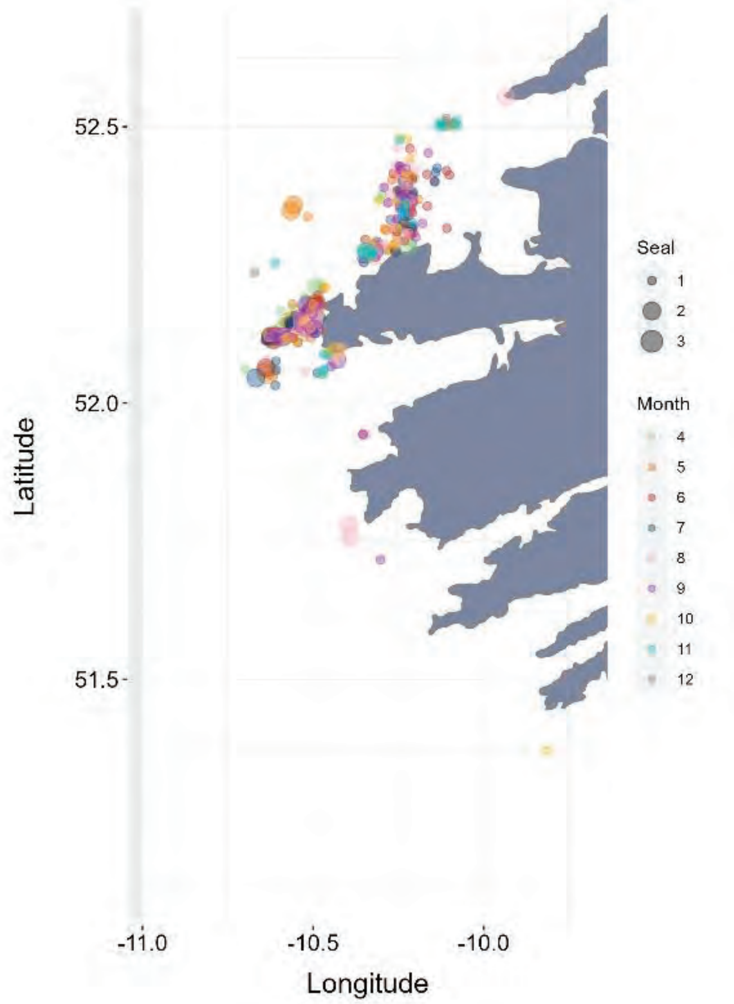


Figure 19. Number and distribution of by-catch of Grey Seal in outer Tralee Bay and Blaskets 2017-2023.

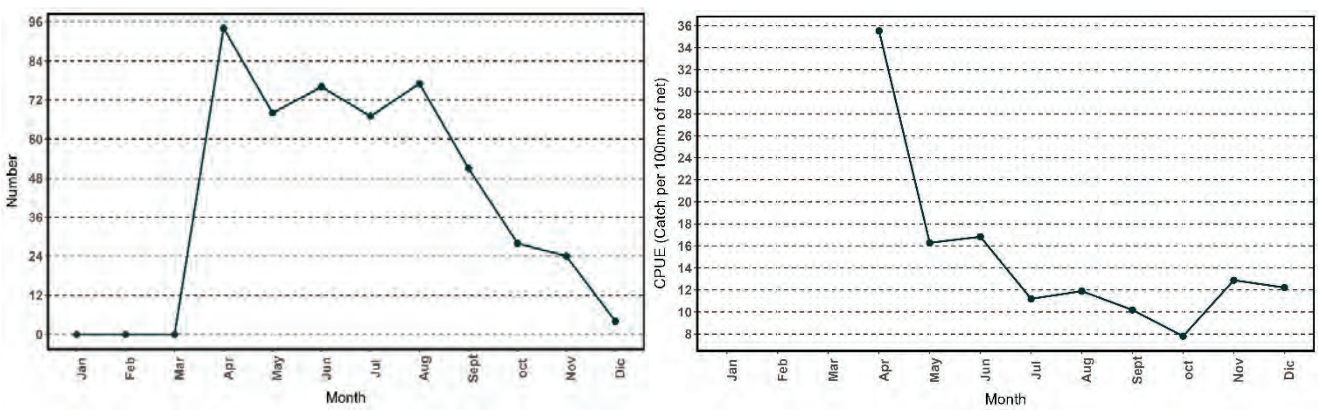


Figure 20. Monthly distribution of by-catch of Grey Seal in outer Tralee Bay and Blaskets in 2017-2023. Numbers caught per month (left) and catch per 100 nm of effort (right).

5.7 *Monitoring of endangered species using acoustic telemetry*

In 2023 a 3 gateway acoustic receiver array was deployed in Tralee Bay to monitor movement of tagged fish into and out of the outer, middle and inner Bay (Figure 21). The distance between the receivers is 400 m and will detect all tagged fish moving across the arrays. To date sting ray and undulate ray have been tagged in the inner Bay from Fenit pier east to Derrymore. Most of these fish were tagged in collaboration with the Tralee Bay Anglers Association 'Tag a Ray day' angling competition (Table 8). Efforts to tag Flapper skate and Angel shark will continue in 2024. The receivers will be recovered and re-deployed in spring 2024.

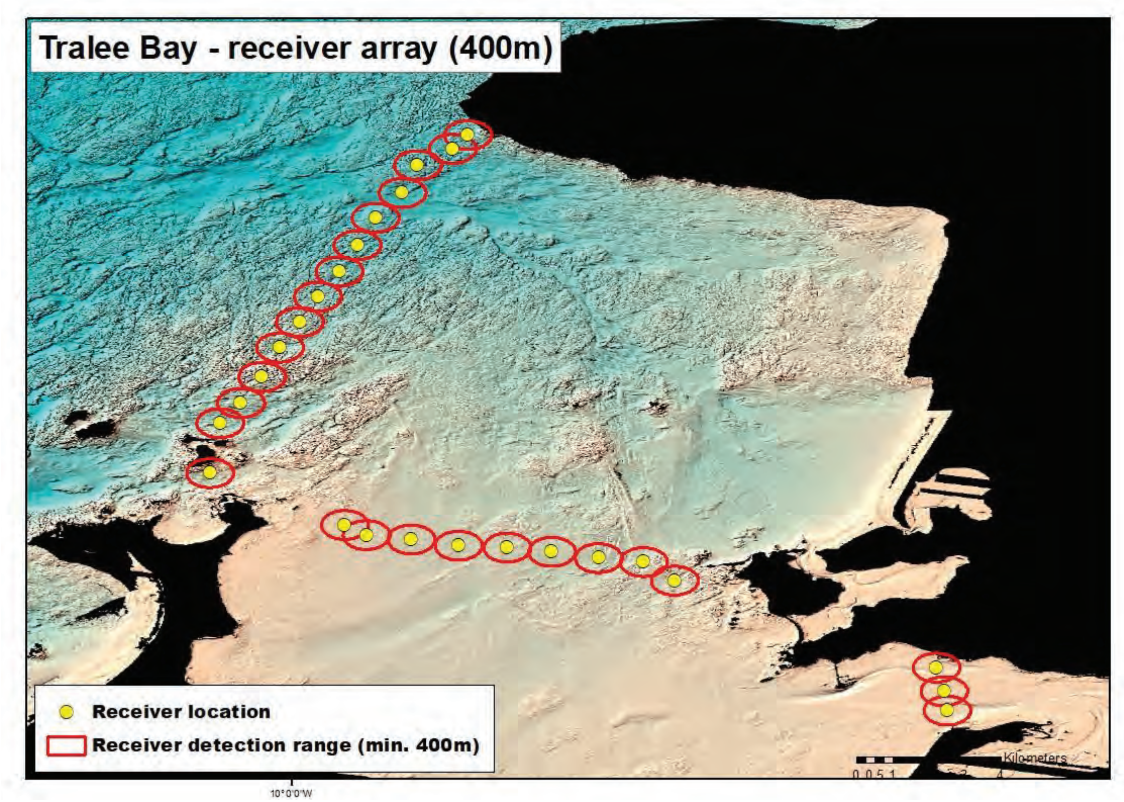


Figure 21. Location of a triple gateway acoustic array deployed in Tralee Bay in spring of 2023. An acoustic receiver has been deployed on the seabed at each point and separate by 400m. The receivers can detect tagged fish moving within 400m of the receivers.

Table 8. Details of fish tagged in inner Tralee Bay in 2023.

Species	Sex	Catch Location	Total number tagged	Acoustic tag Y/N	Floy Tag
Stingray	Male	Derrymore	24	5/24	24/24
Stingray	Female	Derrymore	12	12/12	12/12
Undulate ray	Male	Derrymore, Fenit Pier, Spa	8	2/8	8/8
Undulate ray	Female	Derrymore, Fenit Pier	12	4/12	12/12
Undulate ray	Unknown	Fenit Pier, Spa	2	0/2	2/2

5.8 *Catch rates of crayfish*

National landings of crayfish in 2022 and 2023 were 73 and 69 tonnes, respectively. These landings are the highest since 2004. Monthly catch rates (including all sizes) generally varied from 10-20 fish per nautical mile of net during 2017-2023 (Figure 22). The size distribution data shows variable proportions of the catch are above the minimum size in each year; 34 % in 2017 and 48-57 % in 2018-2023 (Figure 23). 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. The annual average catch rate increased from 9 to 18 crayfish per nautical mile of net between 2017 and 2021 and declined slightly from 2021 and 2023 (Figure 24).

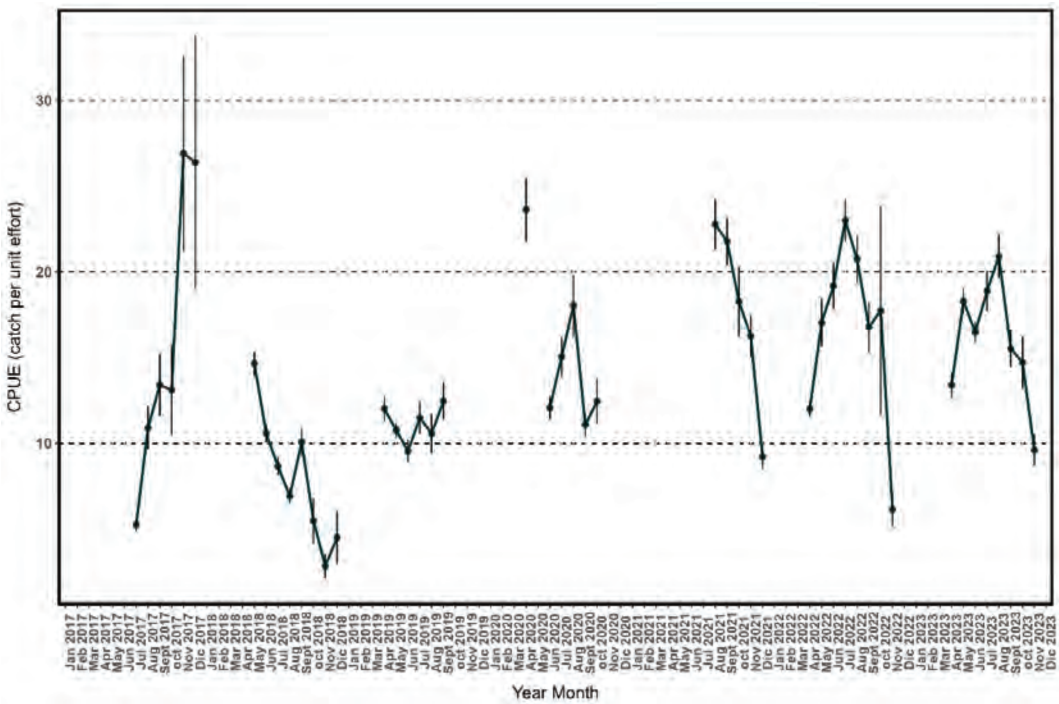


Figure 22. Monthly catch rate (numbers.nmnet^{-1}) of crayfish off the south west coast of Ireland 2017-2023.

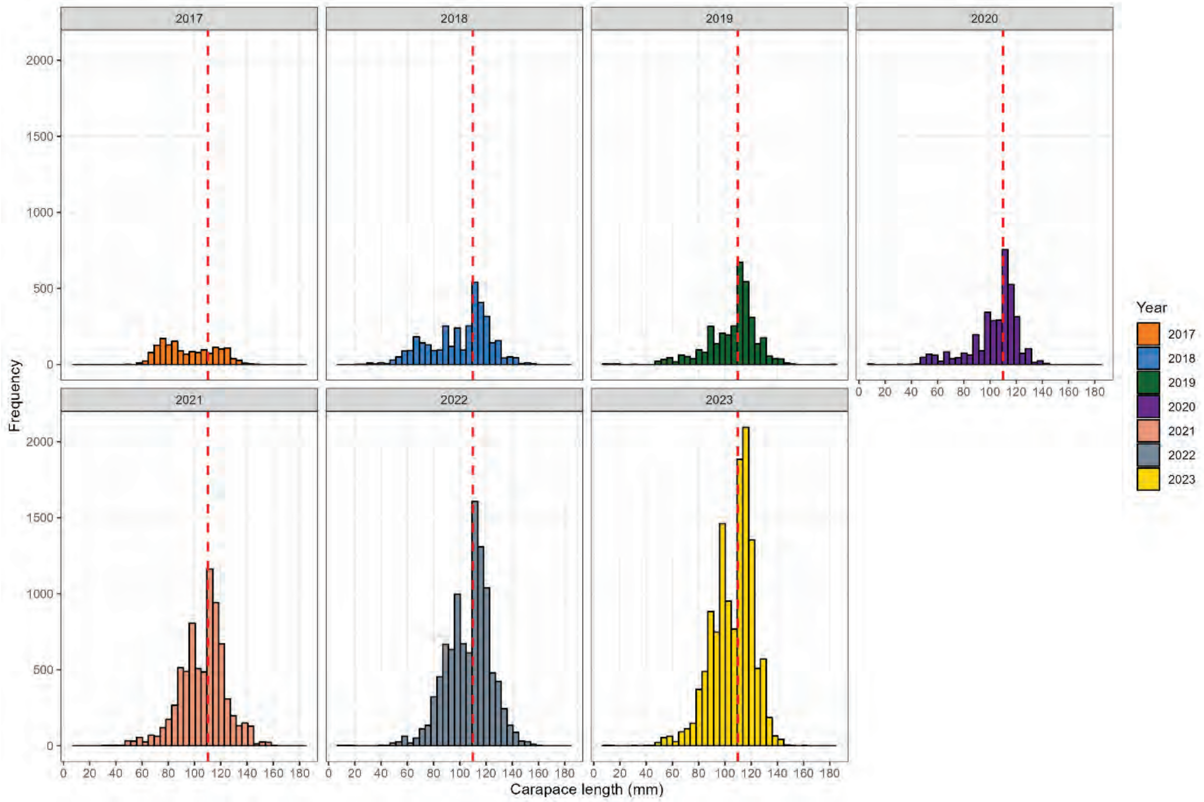


Figure 23. Size distribution of crayfish in the catch off the southwest coast or Ireland 2017-2023.

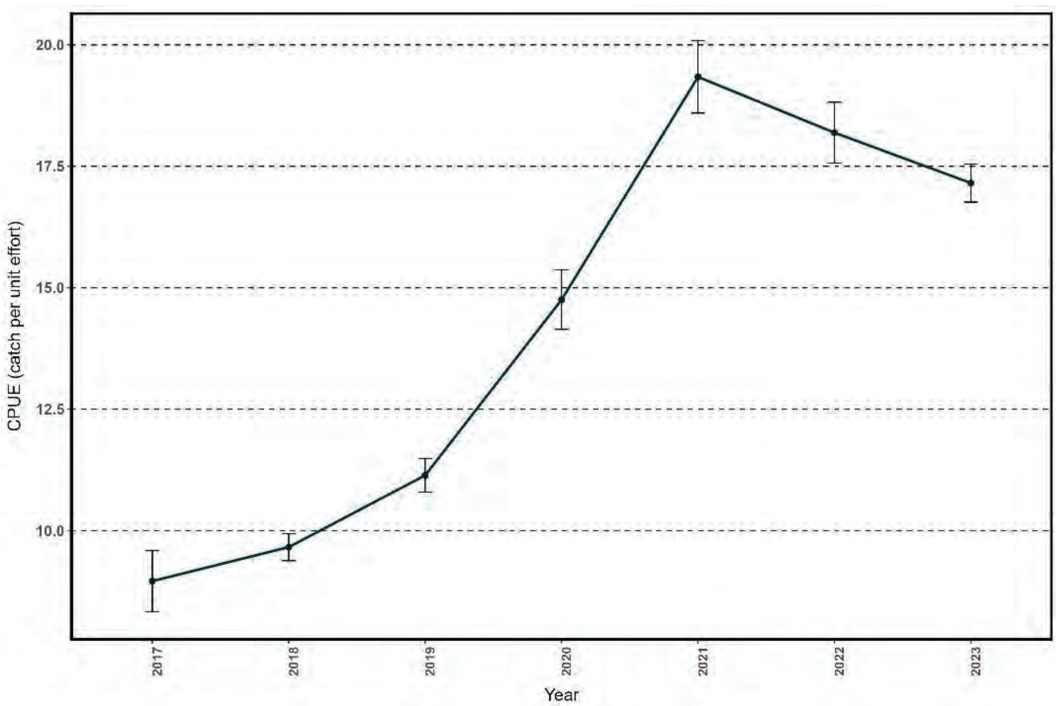


Figure 24. Annual average catch rate (numbers.nmnet^{-1}) of crayfish off the south west coast of Ireland 2017-2023.

6 Spider crab (*Maja brachydactyla*)

6.1 *Management advice*

Spider crab (*Maja brachydactyla*) are managed with a minimum landing size (MLS) of 125 mm carapace length for females and 130 mm for males. These measures are designed to protect juvenile crabs that have not yet gone through terminal moult and should be maintained.

6.2 *Issues relevant to the assessment of the spider crab fishery*

There is no regular monitoring or assessment of spider crab stocks. The main targeted fishery occurs in Tralee Bay. The fishery is seasonal. Spider crab are not aged. The use of size in length based assessments is confounded by the terminal moult when growth stops.

6.3 *Management units*

Spider crab are common on all coast of Ireland. The Tralee Bay fishery is the main targeted fishery in the spring of each year and relies on migration of spider crab from deeper water into shallow sandy areas of Tralee Bay.

6.4 *Management measures*

Spider crab have a terminal moult meaning that they reach a certain size and stop growing. The life span following terminal moult is limited to 2-3 years as the shell ages. As spider crab have a terminal moult any changes in the relationship between MLS and terminal moult size distribution could significantly change the proportion of crabs that achieve a terminal body size larger than the MLS. Although there is no evidence that it is occurring strong size selective mortality, caused by the fishery, could lead to reductions in size at terminal moult.

Spider crab are managed by a minimum conservation reference size which is 125 mm carapace length for female crabs and 130 mm for male crabs. These sizes are designed to protect juvenile crabs that have not gone through terminal moult.

6.5 *Catch rate indicators*

In 2009 catch rates (CPUE) in Tralee and Brandon Bay spider crab fishery increased between March and May, and varied from 3.5-3.8 kg.pot^{-1} between May and September. Discard rates averaged approximately 3.0 kgs.pot^{-1} between May and September and varied from 50-80 % of catch. There was a significant depletion in monthly CPUE suggesting a harvest rate of about 57 % on crabs above the MLS.

Figure 25 shows the locations of monthly sampling on spider crab undertaken in 2022. Skipper self-sampling data indicated that monthly CPUE was 3.5-6.0 kg.pot^{-1}. There was no evidence of decline in CPUE during the fishing season unlike 2009. Discards per unit effort (DPUE) were stable between April and June at around 1.5 Kg.pot^{-1}. This value decreased to less than 1 Kg.pot^{-1}in July (Figure 26).

Size distributions were bimodal especially in April when a lot of small crab were recorded by 1 vessel in particular. Males were larger than females (Figure 27).

Both the catch rate indicators and the size distributions are similar in 2022 and 2009 suggesting no significant change in the status of the stock.

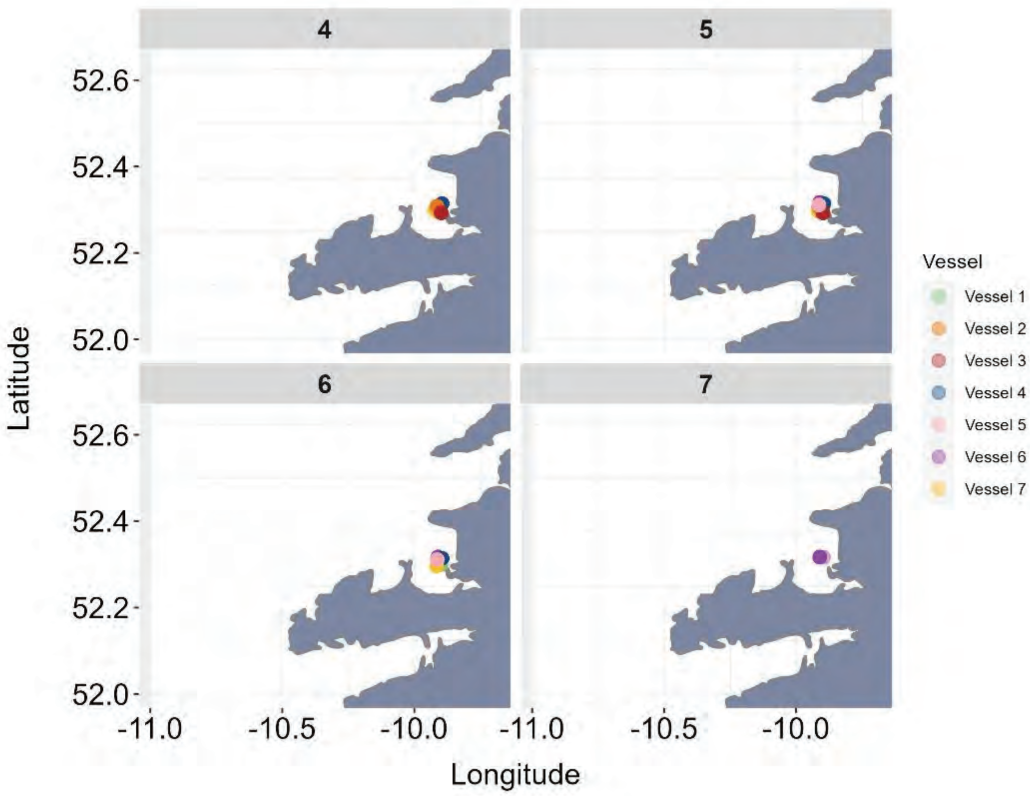


Figure 25. Location of monthly sampling of spider crab catches by Skippers of 7 vessels in 2022.

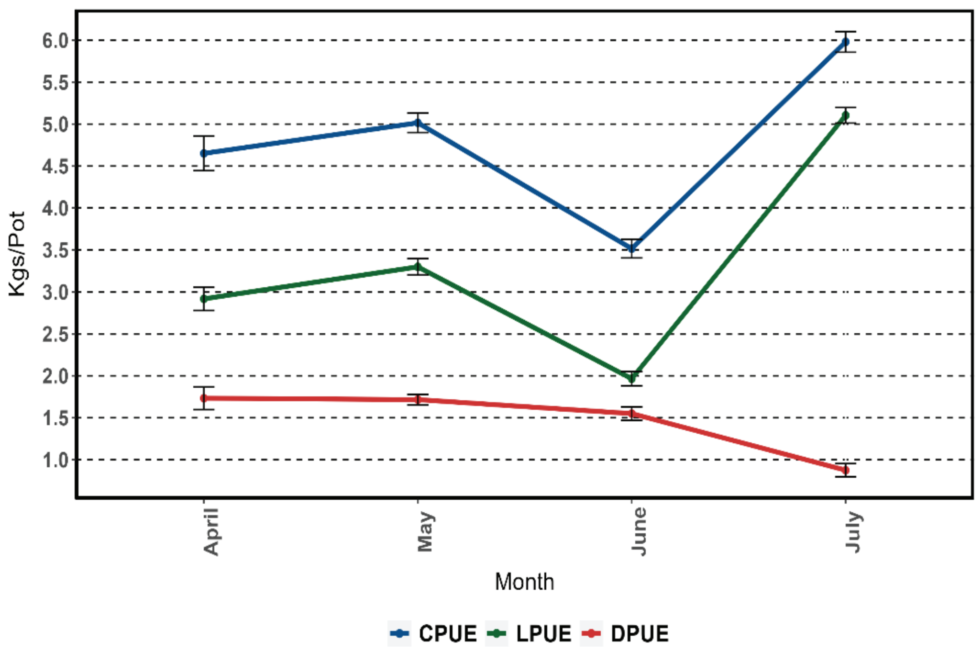


Figure 26. Mean (±standard error) monthly rate of catch (CPUE), landings (LPUE) and discards (DPUE) in the spider crab fishery in 2022.

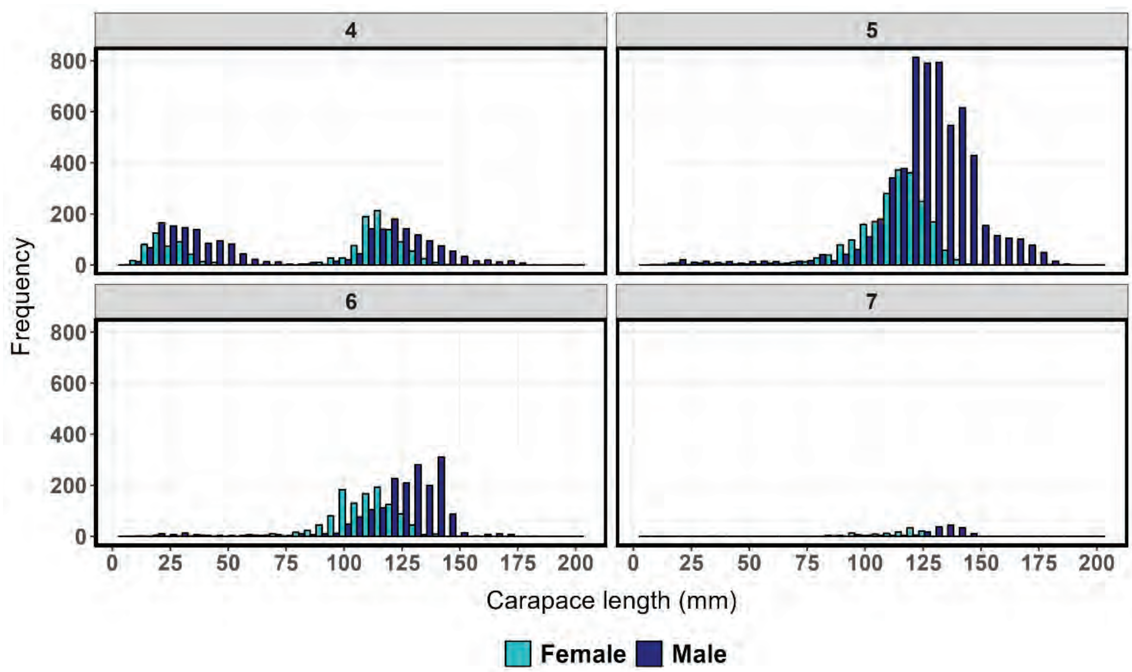


Figure 27. Monthly (April-July) size distribution of male and female spider crabs in the Tralee Bay fishery in 2022. Small crabs were reported by 1 vessel in April.

7 Brown crab (*Cancer pagurus*)

7.1 *Management advice*

The crab fishery is managed by a minimum landing size of 140 mm carapace width. There are kilowatt day effort 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.

Standardised indices 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. These trends are also generally observed in other crab stocks off the Irish coast. The production model assessment was carried in 2021 and has not been updated.

Advice based on the negative trends in stock indices or on the fishing mortality (F/F_{msy}) ratio, in the case of the Malin stock, all indicate the need to reduce fishing mortality. Corresponding landings at F/F_{msy} =1 for the Malin Shelf is 3,900 tonnes (all fleets combined including UK) or 4,500 tonnes using other harvest control rules for stocks where only relative estimates of fishing mortality and trends are available. Using the latter harvest rule landings for the south west coast would reduce to 960 tonnes and landings for the Celtic Sea would reduce to 632 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.

7.2 *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. The size composition of crab in the landings also does not seem to change in response to increased effort or landings i.e. there may not be a fishing mortality signal in these data.

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.

Catch rates are highly variable between vessels, areas, seasons and years making 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 increased precision and to take into account geographic, seasonal and other effects on catch rate.

7.3 *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 28). On the Irish coast these units are identified from tagging data, distribution of fishing activity and larval distribution.

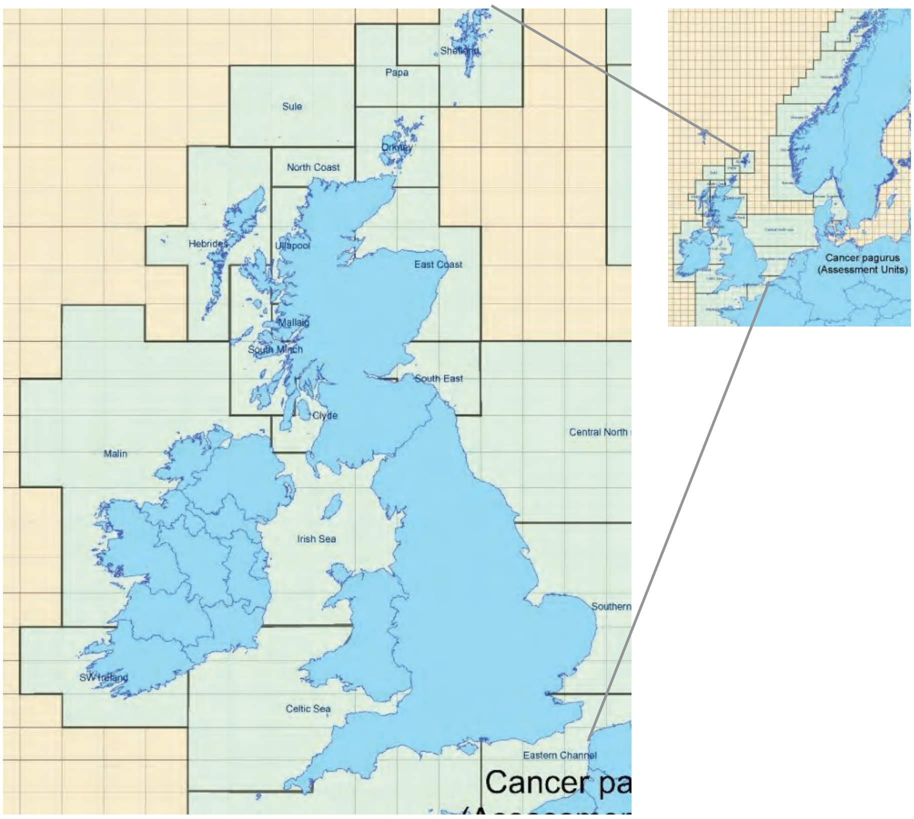


Figure 28. ICES stock assessment units for Brown crab.

7.4 *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.

7.5 *Catch rates*

Sentinel vessel (SVP) data from 2013-2022 and the MI observer data from 2015-2022 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.

7.5.1 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 Kg/Pot in 2022. The MI observer data declined from 3 Kg/Pot in 2016 to 1 Kg/Pot in 2021 (Figure 29). This decreasing trend in LPUE was observed in all stocks (Figure 30), although it seems to have stabilised in the Malin stock from 2019-2022. The new skipper self-sampling programme reports LPUE and DPUE comparable in scale to the SVP and observers, although only two years of data are available. Data for the Celtic Sea displays higher inter-annual variability that the other two stocks, but the decreasing trend is still obvious. The exceptional 2020 mean annual estimates in this area is more likely to be an outlier in the time series. Discards per unit effort (DPUE) showed decreasing trends in both SVP and MI observer data up to 2019, and have hovered around 0.5 Kg/Pot in recent years. LPUE and DPUE of crab caught in gear targeting lobster were relatively stable from 2018 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.

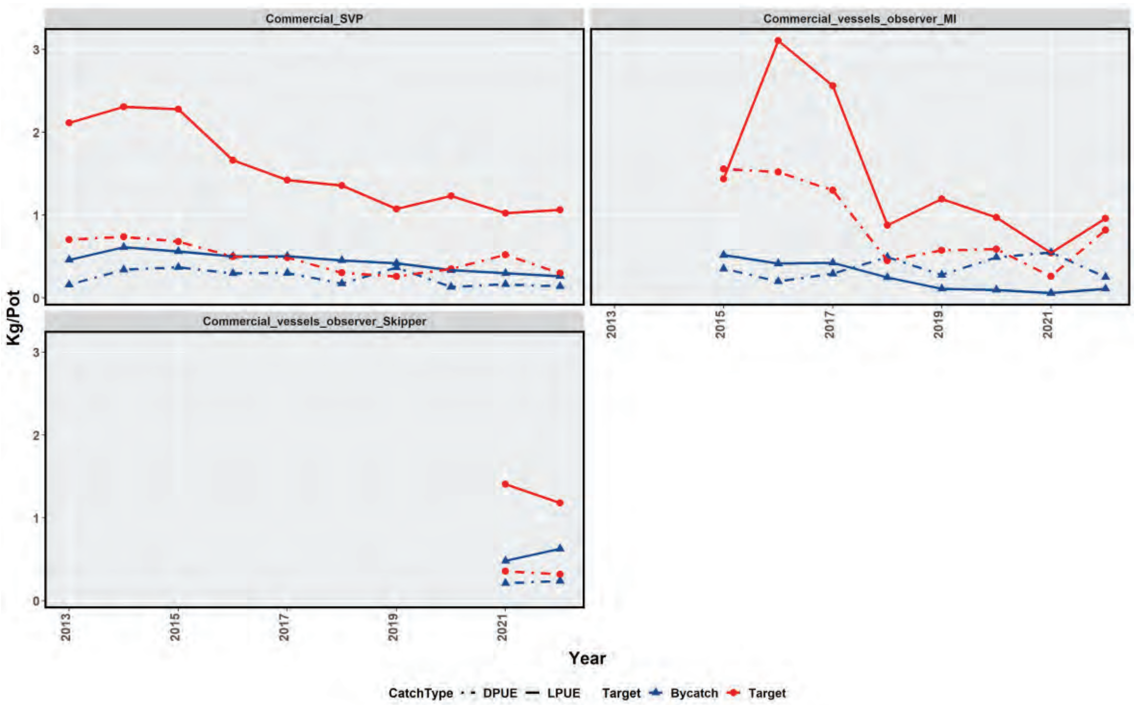


Figure 29. Annual mean LPUE and DPUE (Kg/pot) for SVP, Observer and Skipper self-sampling programme data from trips both targeting brown crab and where brown crab is caught as by-catch during 2013-2022. All stocks are combined.

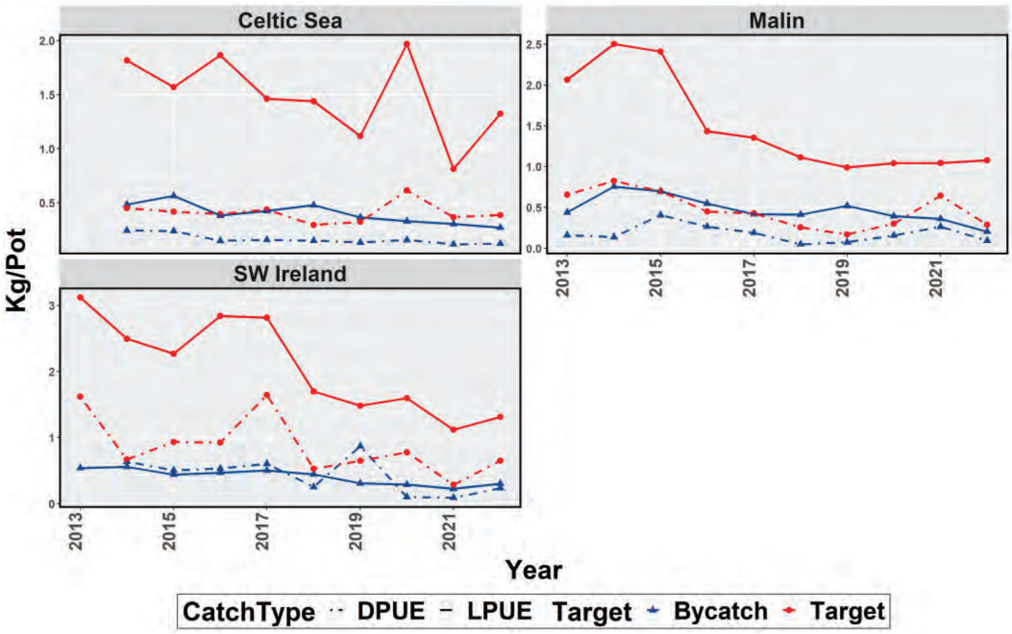


Figure 30. Annual mean LPUE and DPUE (Kg/Pot) by stock area for SVP trips targeting crab and also where crab is caught as bycatch during 2013-2022.

7.5.2 Seasonal trends

Seasonal trends in LPUE in the SVP data are shown in Figure 31. 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.

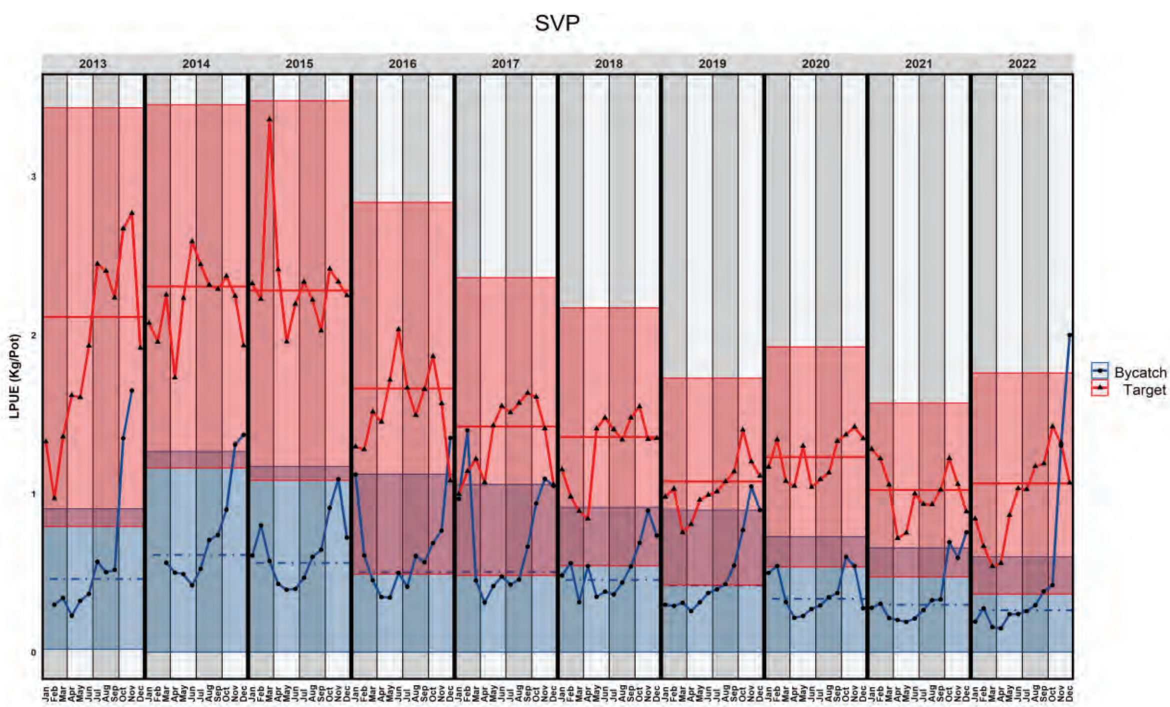


Figure 31. Monthly mean LPUE (Kg/pot) with standard deviation for SVP trips where crab was targeted (red) and captured as bycatch (blue). Horizontal lines in each year show annual means. Year quarters shaded in grey and white.

8 Razor clam (*Ensis siliqua*)

8.1 *Management advice*

Razor clams in the Irish Sea are managed by a minimum landing size of 130mm and weekly quotas. The fishery is closed voluntarily in June. All vessels are required to 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 have been stable between 500-600 tonnes per annum since 2021. There is no evidence of high grading in the fishery. All indicators (daily landings per vessel, catch per hour) showed significant and persistent declines up to 2017 but were stable from 2017-2020. Estimates of biomass varied from approximately 9,000 tonnes in 2017 to between 6,000-7,000 tonnes in 2018-2020 and ~9200 tonnes in 2021-2023. Large size classes were depleted between 2017 and 2018 but were stable or increased between 2018-2023. Using the ICES 2/3 harvest control rule, applied to the survey biomass, with penalty clause limiting annual change in landings to 20 % or less, landings should not exceed 763 tonnes (8.6 % exploitation) in the period July 1st 2023 to May 31st 2024.

The south Irish Sea fishery opened in 2010 and expanded up to 2013. A strong recruitment event in Rosslare Bay, which probably occurred in 2014, was observed in the 2017 survey and biomass increased significantly between 2017 and 2020 from 2,000 to 6,300 tonnes. The biomass estimate for 2023 was 5,001 tonnes. A further 1,524 tonnes was estimated in the Curracloe bed in 2023. The ICES 2/3 rule advises landings of 173 tonnes for the period July 2023 to May 2024 when applied to the 2022 landings. This is an exploitation rate of 2.6 %.

Many razor clam fisheries or potential fisheries occur within or close to Natura 2000 sites. The conservation objectives for species and habitats in these areas are integrated into razor clam fishery management advice. In the north Irish Sea bivalve fauna caught as by-catch in the fishery occurs at very low densities in Dundalk Bay SPA relative to other areas. An area of Dundalk Bay was closed to fishing in 2023 to allow monitoring of changes in marine communities following removal of fishing pressure.

8.2 *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 *Ensis siliqua*.

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

8.3 *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, Ballinakill Bay, Killary Harbour, Rutland sound Co. Donegal, Waterford estuary and off Iniskea Islands and Inisbofin.

8.4 *Management measures*

New management measures were introduced for the Rosslare - Curracloe fishery in December 2014. These included 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.

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.

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

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).

8.5 *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 Asia. 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.

8.5.1 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 from 14 in 2012 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. Landings have remained stable in 2020-2023 at ~500-600 tonnes. The Dundalk Bay and Gormanstown production areas account for most of the landings (Figure 32).

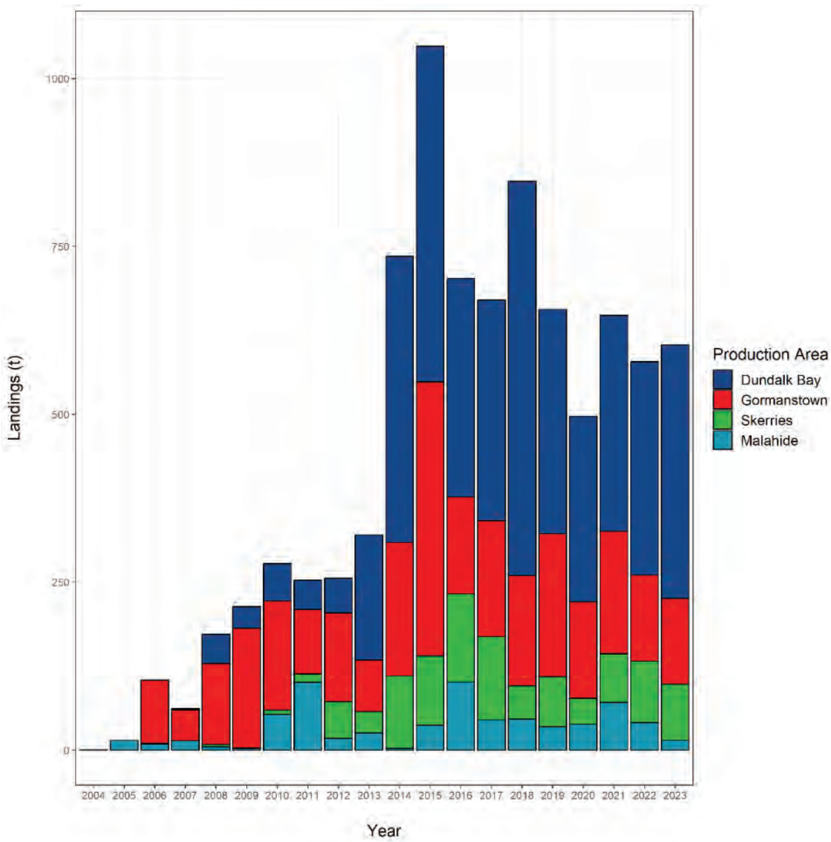


Figure 32. Annual landings of *Ensis siliqua* in the north Irish Sea (NIS) 2013-2023 sourced from SFPA logbook, and sales notes data. Figures reported have been updated according to latest sales note data.

8.5.2 Survey 2023

A survey encompassing all of the areas which are commercially fished for Razor clams in the north Irish Sea was completed in June 2023. The survey follows the same design to that used in 2017-2022 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 completed over a 4-5 day period, depending on weather.

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 on 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 2017-2023 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

8.5.2.1 Biomass 2017-2023

Survey estimates of biomass, since surveys began in 2017, have varied from 5,500 to over 9,000 tonnes.

Estimates for 2021 and 2022 were revised downwards in 2023 following a cross check between different analytical methods. The biomass time series, following revision of 2021 and 2022, now shows a more gradual increase from 7,442 tonnes in 2021 to 8,450 tonnes in 2022 (Figure 33).

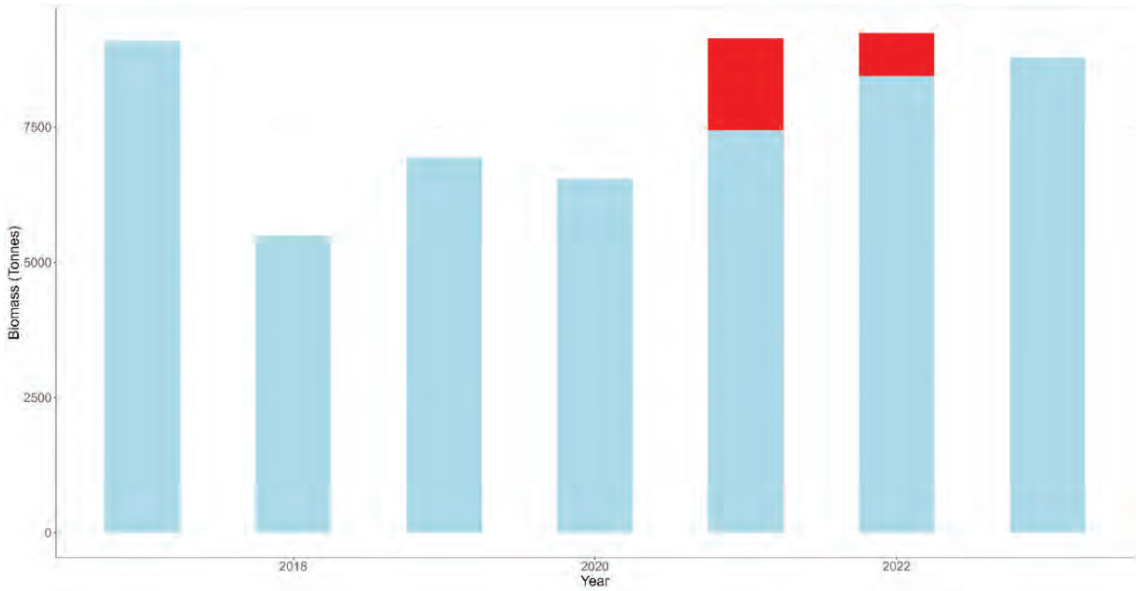


Figure 33. Survey estimates of biomass of razor clams in the north Irish Sea 2017-2023. Revised estimates for 2021-2022 following re-assessment (the revised estimates now exclude the portion shown in red).

From the 2023 survey biomass of all size classes of razors, uncorrected for dredge efficiency and which is presumed to be 100 %, varied from 0-0.5 kgs.m^{-2} (Figure 34). The distribution of high density patches was similar across size ranges up to 160 mm. Razors above 180 mm and 200 mm were more abundant in the northern limit of the survey zone (Dundalk), and at Gormanstown just north of Drogheda (Figure 34). The estimated total biomass in 2023 was 8,792 tonnes, with 90 % of the total biomass above the 130 mm MLS. The trends in stock biomass of razor clams from 2017 to 2023 are displayed in Figure 35.

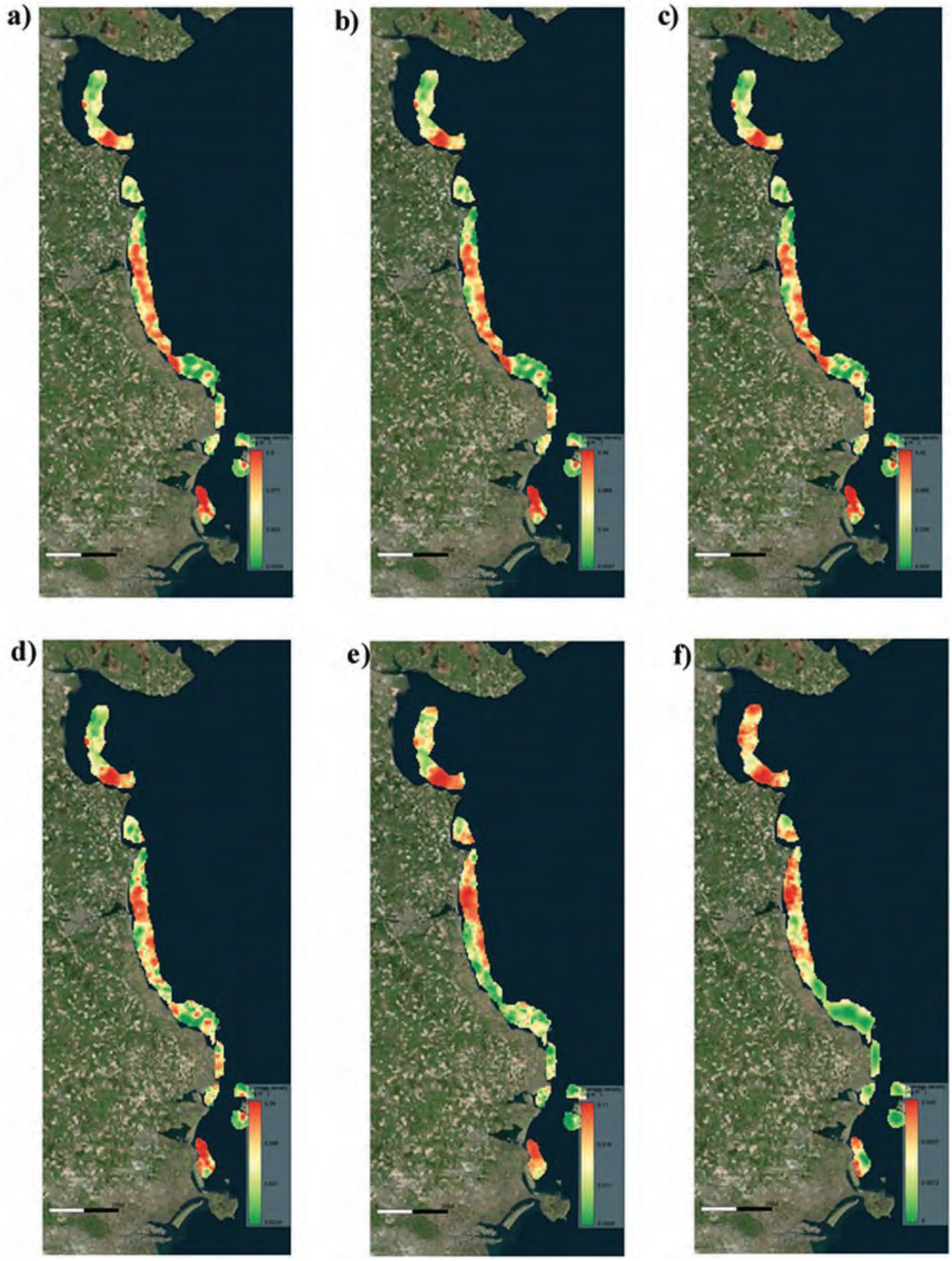


Figure 34. Distribution of *Ensis siliqua* in the North Irish Sea in June 2023 for a) all size class, b) >130 mm, c) >140 mm, d) 160 mm, e) 180 mm, f) 200 mm.

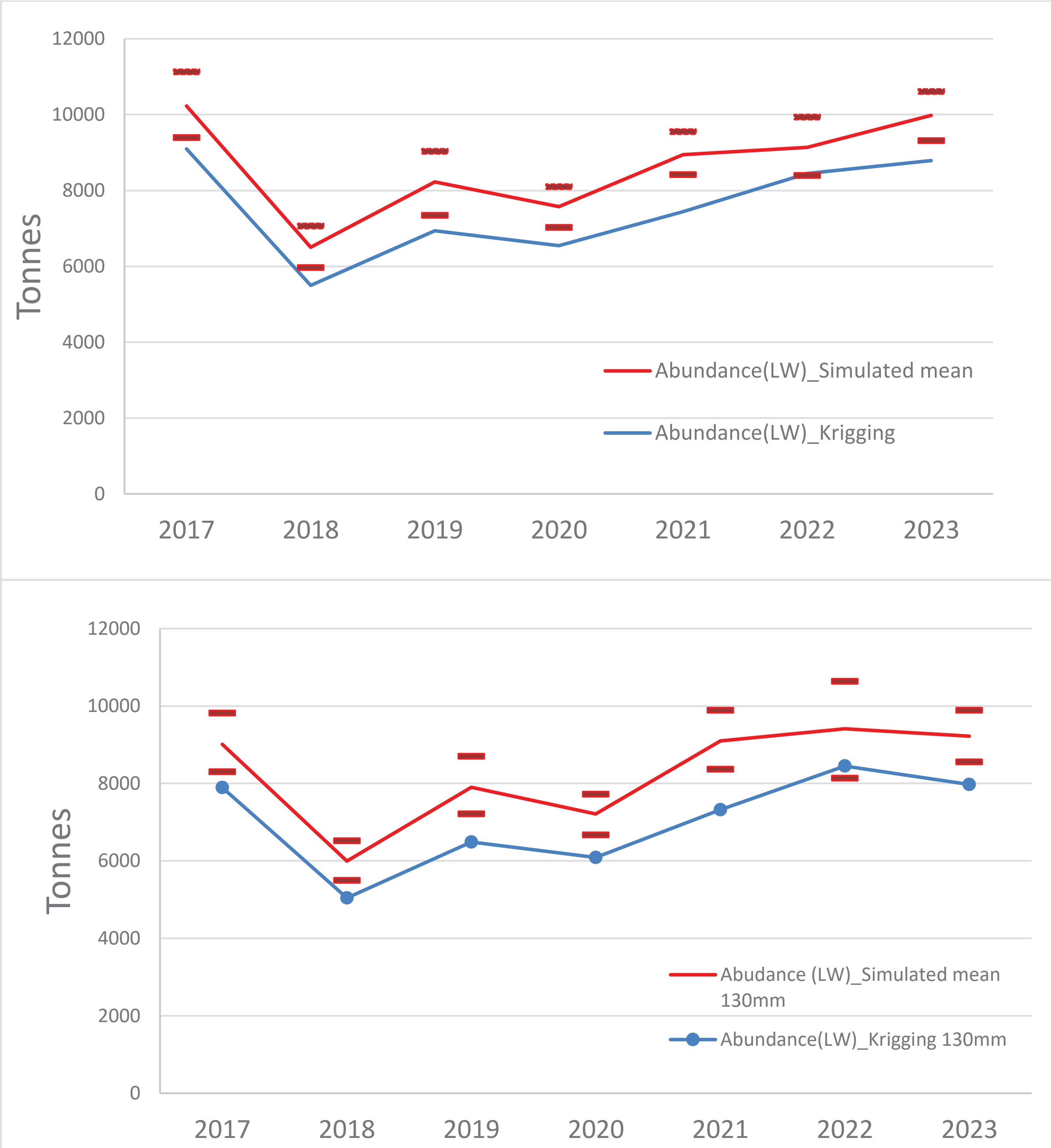


Figure 35. Trends in stock biomass of razor clams 2017-2023 in the north Irish Sea for all size classes (top) and size >130 mm (bottom). Krigging estimates are regarded as more reliable and precautionary.

8.5.2.2 Size distribution

The size distribution of razor clams in the North Irish Sea in 2023 shows two main cohorts, one at ~160 mm, similar to the 2022 survey, and a significant recruitment event at ~110 mm not detected in the previous year's surveys (Figure 36). Densities of razors above the MLS of 130 mm remains similar to that recorded during the 2022 survey. A smaller cohort in the 2023 survey is also apparent at ~60 mm, although numbers are low, as these sizes are generally not selected by the gear (Figure 36).

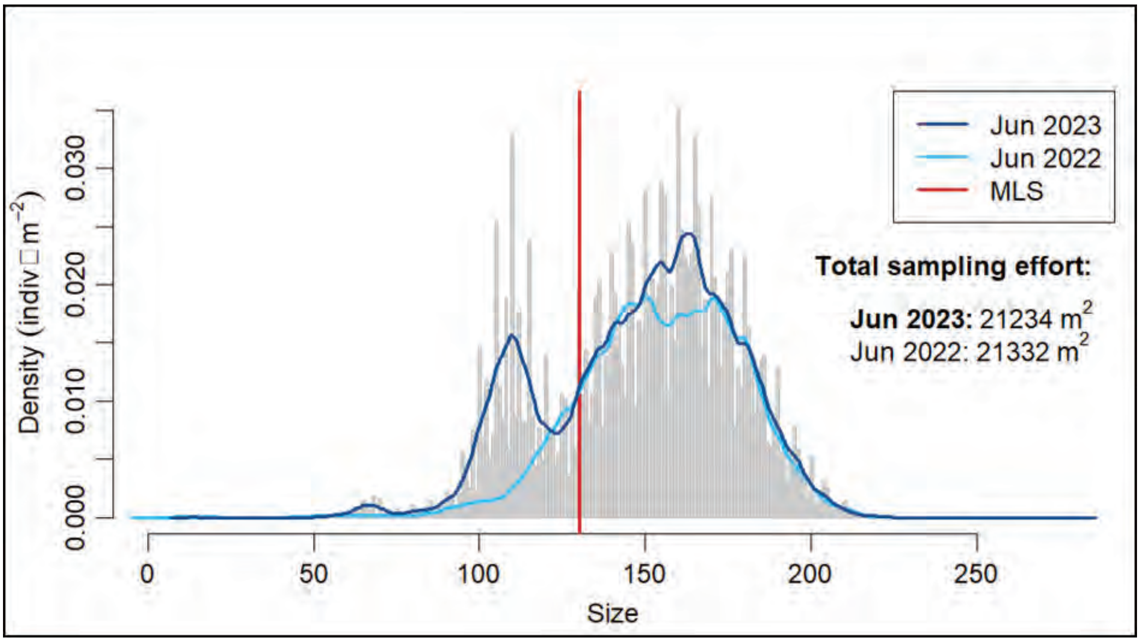


Figure 36. Size distribution of the razor clam, *Ensis siliqua* in the North Irish Sea in June 2023 and June 2022. The red line indicates the MLS of 110 mm.

8.5.3 Catch advice

The harvest control rule currently used for razor clams is the ICES 2/3 rule (ICES 2022). This is the mean survey biomass in the two most recent years (2022, 2023) divided by the mean biomass in 3 years (2019-2021) previous to that. Where this rule allows for greater than 20 % increase in landings over the previous year a 20 % precautionary cap is applied which limits annual change to 20 % of the previous year.

Table 9 shows landings, biomass, exploitation and catch rate indicators for razor clams in the north Irish Sea from 2015 to May 2023 and biomass, exploitation and catch rate indicators until July 2024. The landings in the period July 2022 to May 2023 was 767 tonnes which was 131 tonnes over the advised TAC for 2022-2023 (MI Advice note 2022). The advised TAC for 2023-2024 is for the period July 2023 to May 2024. No penalty is applied for over advised TAC landings in 2022-2023. The 2/3 rule is applied to the 2022-2023 advice (636 tonnes). As the 2/3 rule allows for a 23 % increase in landings the 20 % cap associated with the 2/3 rule is applied. The advised TAC for 2023-2024 is therefore 763 tonnes. This represents an exploitation rate of 8.7 %.

Table 9. Landings, biomass, exploitation and catch rate indicators for razor clams in the north Irish Sea. The catch advice rules are based on ICES WKLIFE as described above.

Year	Landings (tonnes)	June Biomass (tonnes)	2/3 rule	% Exploitation	SRD data (kg.day^{-1})
2015	1,100				220
2016	700				204
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	**7,442**[1]		7.12	-
2022-2023	767	8,450	636	9.08	201
2023-2024		8,794	763	8.68	

1: biomass revised in 2023.

The 2/3 advice rule is looking at changes in biomass only and not in size and age structure. As the value of clams is significantly correlated to size (grade) managing outtake so that the biomass of larger size grades is optimised by balancing fishing mortality and growth would be a better basis for advice. Development of this advice will involve obtaining new data on the biological parameters of razor clams.

8.5.4 Spatial closure Dundalk Bay

In 2023 an area of Dundalk Bay was closed to fishing for razor clams, and use of other towed bottom contacting fishing gears, to evaluate if changes in the structure of infaunal benthic communities would occur after fishing activity was removed (Figure 37). A monitoring programme will be established.

The closed area is 6 km^2 in extent and includes intertidal fine sands with *Angulus tenuis* and sub-tidal fine sands with *Fabulina fabula* and slightly deeper very fine sands with *Owenia fusiformis* and *Nephtys hombergii* communities.

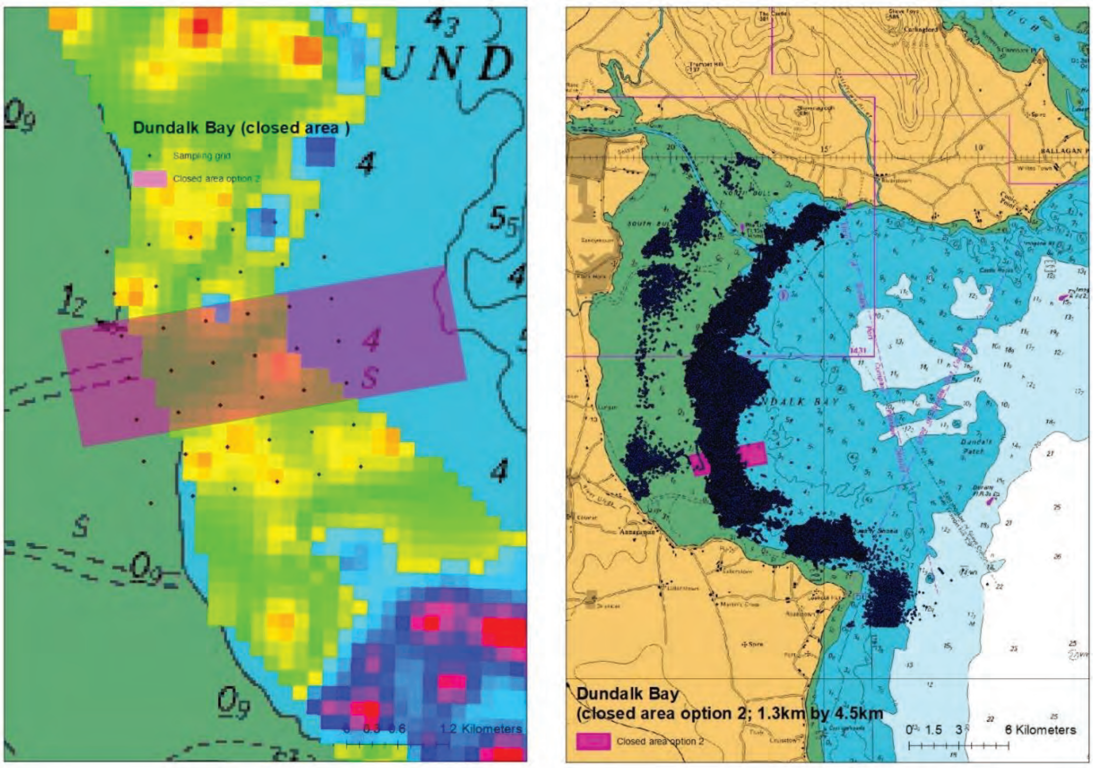


Figure 37. Left: Area closed to razor clam (and other mobile fishing gears) (shaded) in Dundalk Bay from 2023 (FND 1/2023; Dundalk Protected Area). Gridded fishing activity, derived from iVMS data, is shown. Right: closed area and raw iVMS data showing distribution of cockle and razor fishing prior to the closure.

8.6 *South Irish Sea*

8.6.1 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, but increased in 2020 to 150 tonnes, mostly from Curracloe (Figure 38). Landings in 2021 were about 80 tonnes and approximately 140-150 tonnes in 2022 and 2023. The Waterford estuary fishery was closed by court order in 2019.

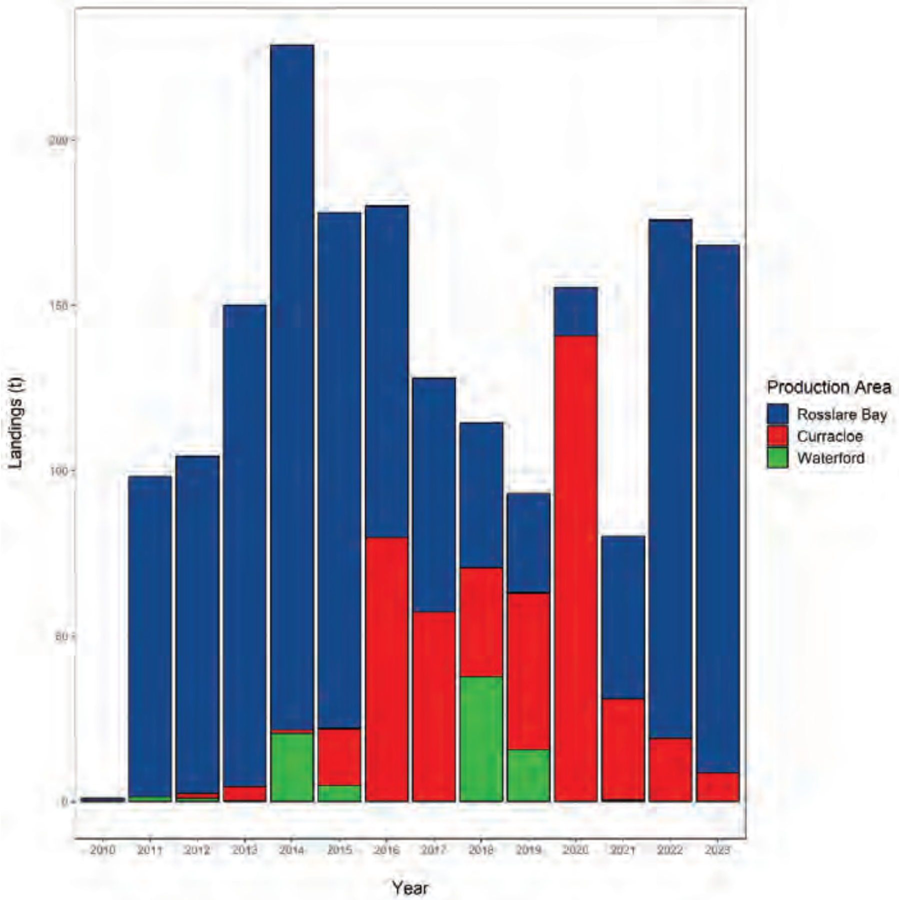


Figure 38. Landings (tonnes) of razor clams in the South Irish Sea by classified production area (CPA) in 2010 to 2023. Source: Logbooks/ Sales notes. CPA is assigned by port of landing.

8.6.2 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 full extent of the beds are included in both surveys where possible.

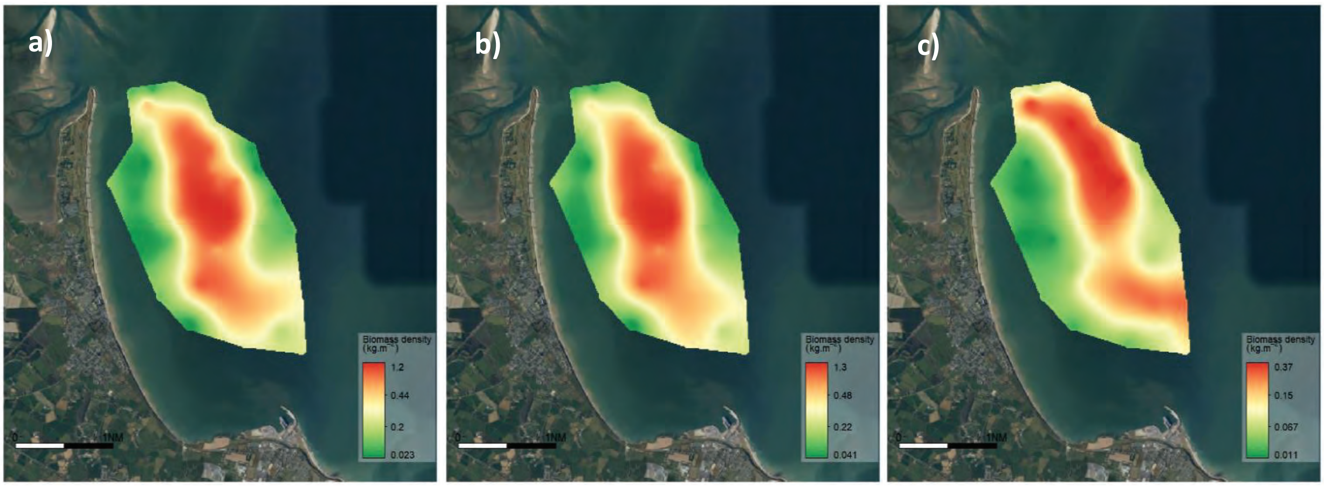
8.6.2.1 Rosslare Bay

The razor bed of Rosslare was surveyed on the 1st and 7th of September 2023. A total of 44 tows were undertaken, with a single hydraulic dredge of width 1.25 m. The survey encompassed a total area of 12.1 km^2 and a total sampling effort of 1,318 m^2 (Table 10, Figure 39). Biomass of all size classes of razors, assuming a dredge efficiency of 100 %, varied from 0-1.3 $kgs.m^{-2}$. The biomass estimate in 2023 was 5,001 tonnes, the majority of which (92 %) was above the 130 mm MLS.

Table 10. Estimates of biomass of razor clams in Rosslare Bay in September 2023.

Ensis siliqua	Biomass		95% HDI inf	95% HDI sup
	Mean	Median		
Biomass_*Ensis siliqua*	5,001.0	5,122.0	4,368.0	6,001.0
Biomass_>130mm_*Ensis siliqua*	4,594.1	4,615.0	3,985.0	5,351.0
Biomass_>150mm_*Ensis siliqua*	1,496.0	1,526.0	1,297.0	1,747.0

Figure 39. Distribution of *Ensis siliqua* in Rosslare Bay in in 2023, a) all size class, b) >130 mm and c) >150 mm.



Densities of the main cohort of razor clams in the Rosslare bed decreased and showed some evidence of growth compared to the 2022 survey results (Figure 40). There was no evidence of recent recruitment as densities of small razor clams were low.

Trends in biomass show an increase from ~2000 tonnes in 2017 to approximately 6,000 tonnes in 2019. Biomass has remained relatively stable from 2019 to 2023 (Figure 41).

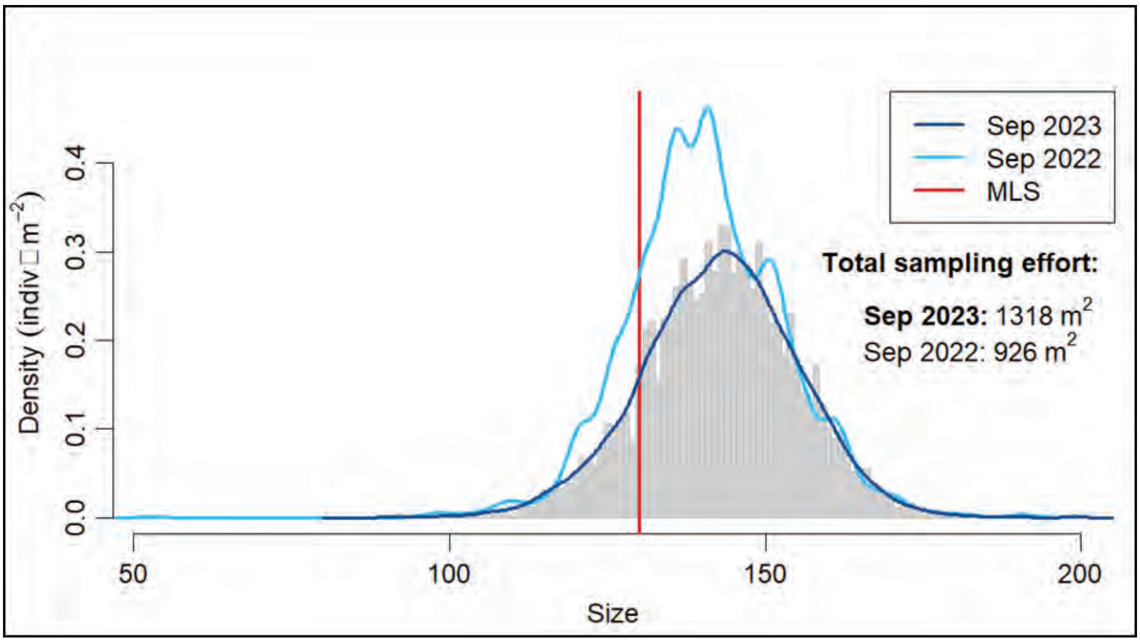
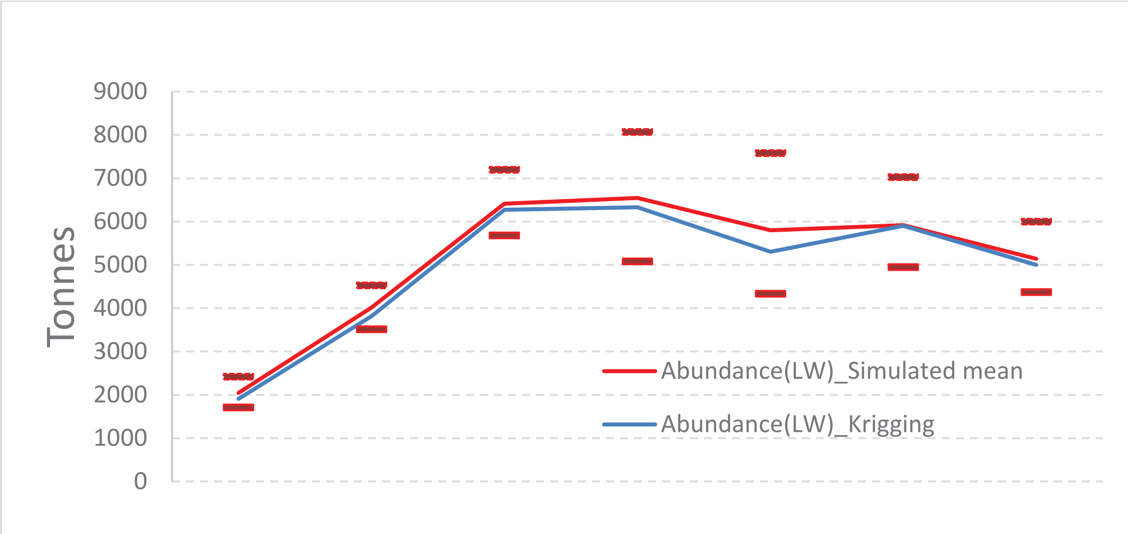


Figure 40. Size distribution of razor clams (*Ensis siliqua*) in the Rosslare Bay 2023 with size data from 2022 for comparison. Data are standardised to sampling effort regardless of its spatial distribution.



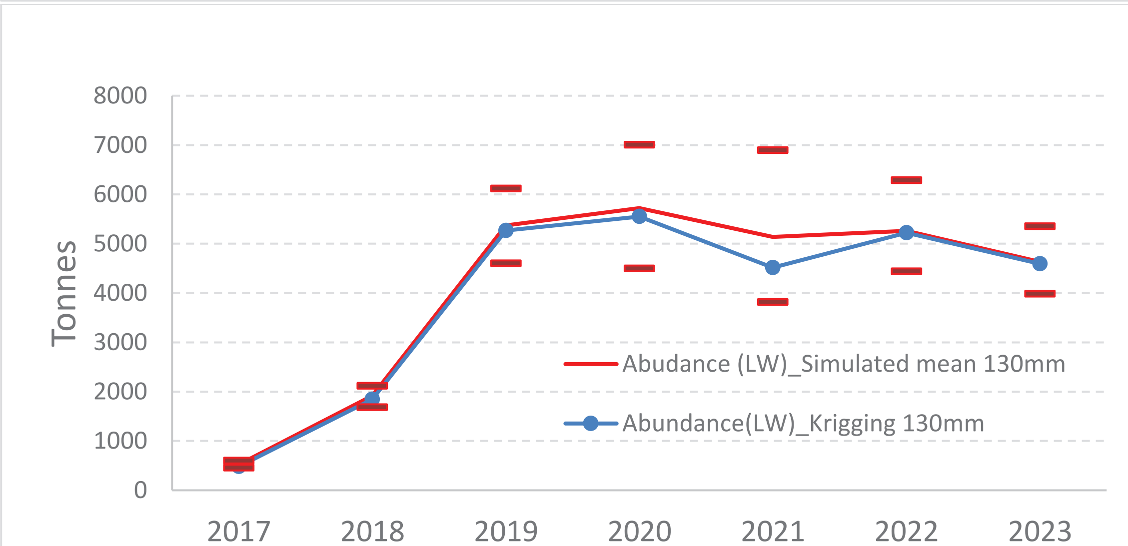


Figure 41. Estimates of biomass of razor clams (*Ensis siliqua*) in Rosslare Bay in 2017-2023 for all size classes (top) and size >130 mm (bottom).

8.6.2.2 Curracloe

The razor bed off Curracloe was surveyed on the 30th August and 7th September 2023. A total of 62 tows were undertaken, with a single toothless dredge of width 1.25 m. The survey encompassed a combined area of 18.8 km^2 and a total sampling effort of 1,988 m^2 (Figure 42). The survey area encompassed during the 2023 survey is similar to the one sampled in 2021. In the 2022 survey, the southern limit of the Curracloe bed could not be sampled, and thus, the biomass estimate from 2022 is not comparable (Figure 44).

Table 11. Estimates of biomass of razor clams at Curracloe in September 2023.

	Biomass		95% HDI inf	95% HDI sup
	Mean	Median		
Biomass_*Ensis siliqua*	1,524.4	1,535.2	1,317.5	1,790.8
Biomass_>130mm_*Ensis siliqua*	1,401.9	1,417.4	1,170.9	1,694.6
Biomass_>150mm_*Ensis siliqua*	938.7	1,107.9	878.7	1,336.4

Biomass of all size classes of razors varied from 0-0.35 kgs.m^{-2} (Figure 42). Distribution of high density patches is similar across size ranges and occurred in the centre of the survey area (Figure 42). The estimated biomass was 1,524 tonnes, the majority of which (91.9 %) was above the 130 mm MLS (Table 11).

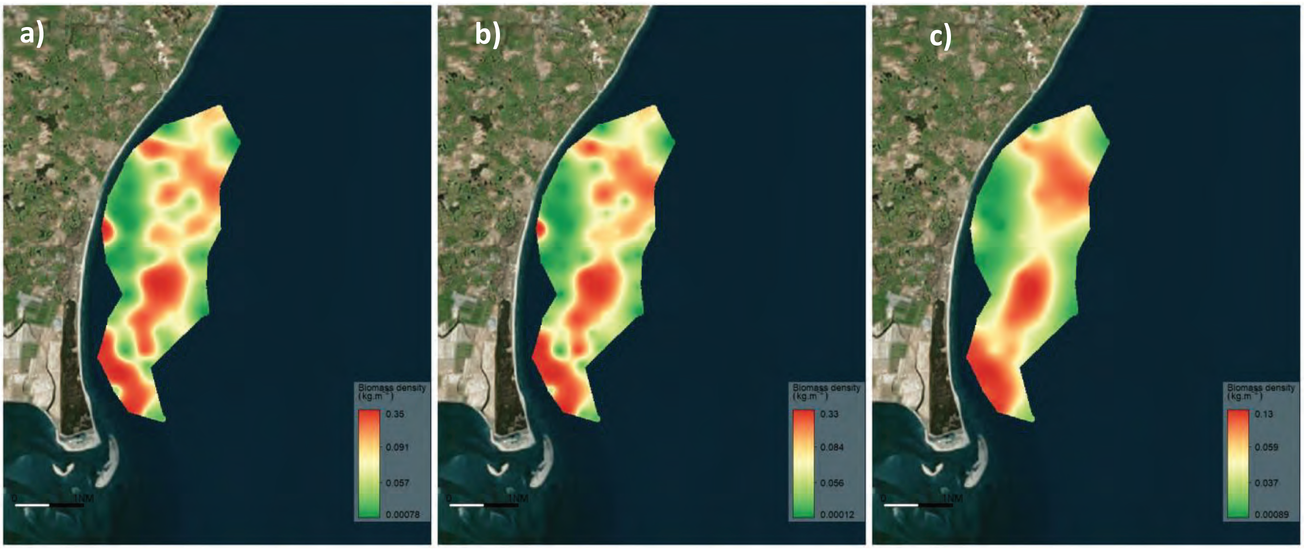


Figure 42. Distribution of *Ensis siliqua* in Curracloe in 2023, a) all size class, b) >130 mm and c) > 150 mm.

The size distribution of razor clams in Curracloe in 2023 resembles the size distribution of the 2022 survey, but significantly higher densities were recorded (Figure 43). The limited number of tows sampled from the south of the bed during the 2022 survey, due to the presence of static gear restricting access, explains this difference. There was no evidence of recent recruitment as densities of small razor clams were low.

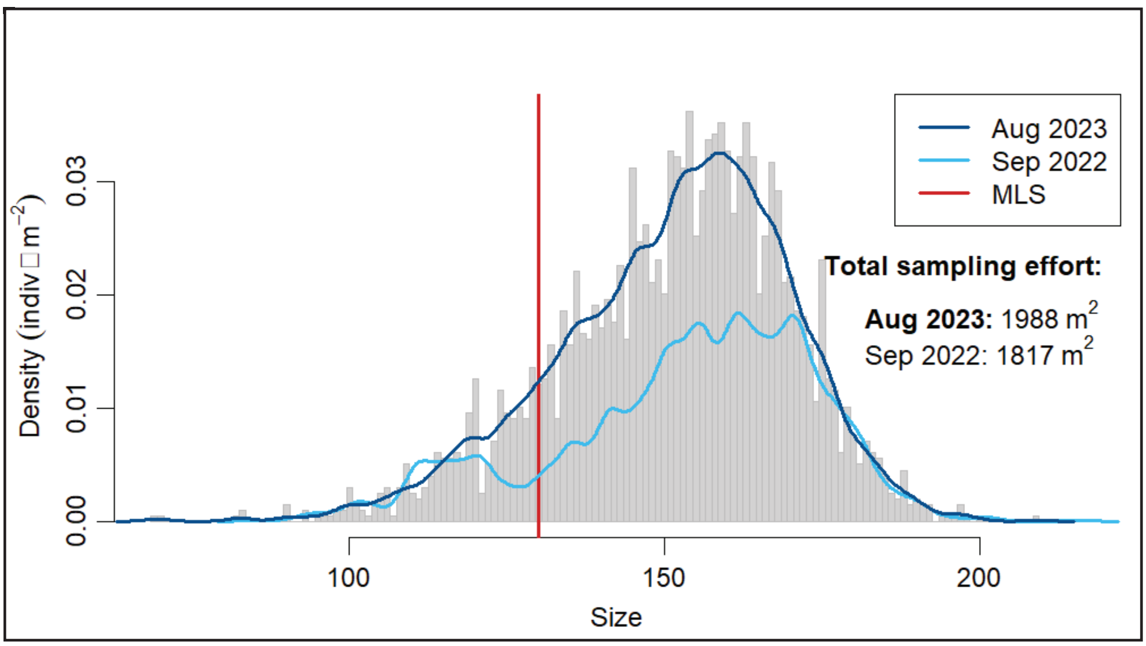


Figure 43. Size distribution of razor clams (*Ensis siliqua*) in Curracloe for 2022 and 2023. Data are standardised to sampling effort regardless of its spatial distribution.

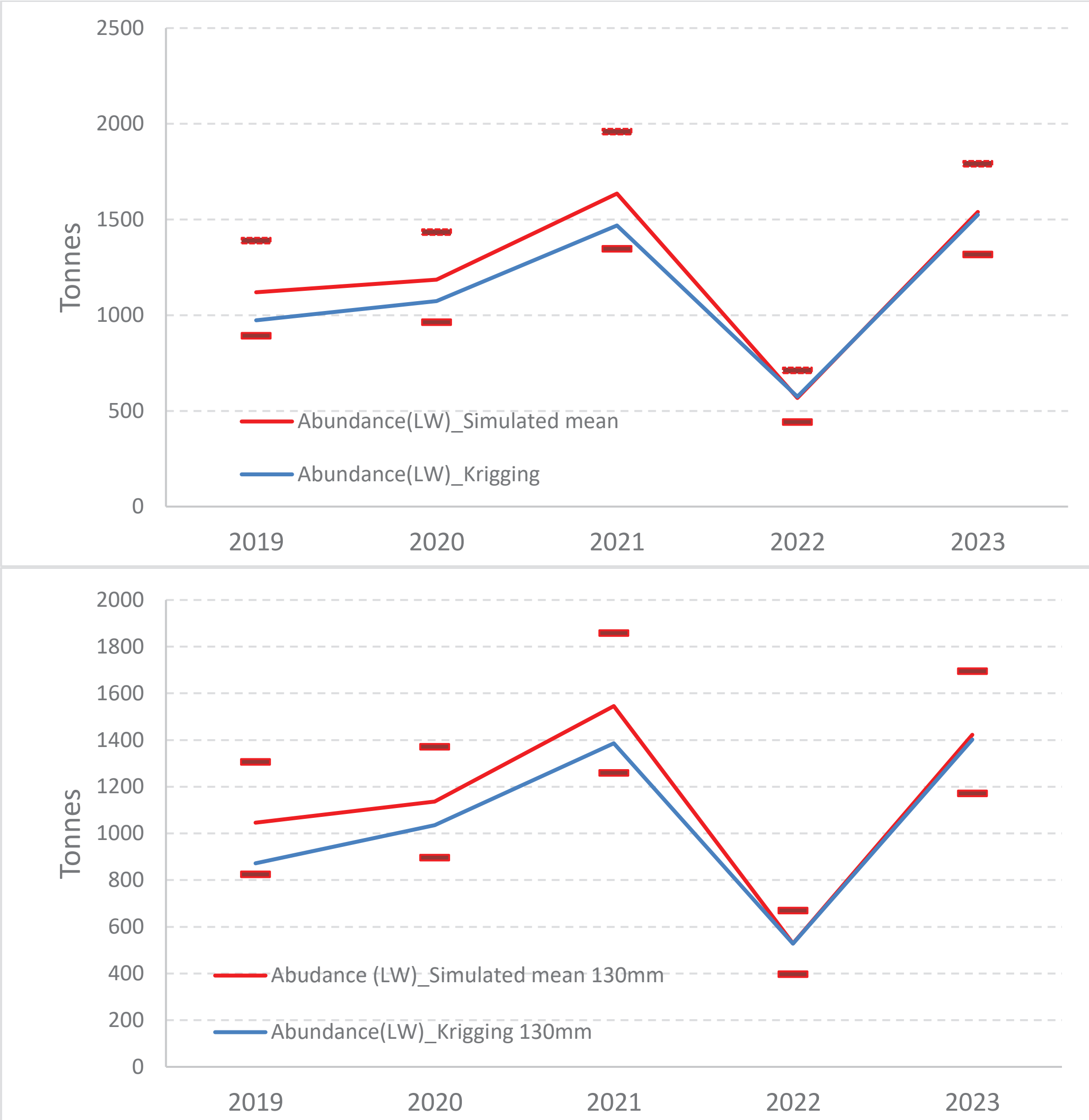


Figure 44. Estimates of biomass of razor clams (*Ensis siliqua*) in Curracloe combined in 2019-2023 for all size classes (top) and >130mm (bottom). The southern edge of the beds was not surveyed in 2022.

8.6.3 Catch advice

Landings for the previous advice period of July 2022 to May 2023, was 185 tonnes (Table 12). The ICES harvest control rule ("two-over-three") estimates advisory landings of 173 tonnes for the period July 2023 to May 2024 when applied to the previous TAC period (July 2022 to June 2023) landings. This is an exploitation rate of 2.6 % compared to 8 % in the North Irish Sea.

Table 12. Landings, biomass and exploitation rate of razor clams in the south Irish Sea 2017-2023.

Year	Landings	Total	2/3 catch advice	% Exploitation
2017	130	1,907		6.82
2018	100	3,818		2.62
2019	70	7,240		0.97
2020	160	7,404		2.16
2021	30	6,767		0.44
2022	125	6,463		1.93
Mid 2022-Mid 2023	185	6,463		2.86
Mid 2023-mid 2024		6,525	173	2.65

9 Cockle (*Cerastoderma edule*)

9.1 *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 a biomass less than 1,000 tonnes. TACs of 17-33 % of biomass apply when biomass is over 1,000 tonnes. The fishery closes on November 1st or if the average catch per boat per day, over a 5 day period, 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 permitted vessels carry iVMS on board.

The stock is assessed by annual survey. Trends in other ecosystem indicators (benthic habitats, bird populations) are integrated into management advice and the FNP. The zero TAC at a biomass <1,000 tonnes is to provide spawning stock for the following Autumn and Spring spawning seasons and to protect food sources for overwintering oystercatchers.

Pre-fishery survey estimate of cockle biomass in 2023 was 2,603 tonnes an increase of 777 tonnes on the 2022 biomass (1,826 tonnes). The TAC and landings in 2023 was 867 tonnes.

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 before they are opened because of their potential effects on habitats and birds.

9.2 *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.

9.3 *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.

9.4 *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. 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 periodically as part of the management plans and the prospect of an annual fishery depends on 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.

9.5 *Dundalk Bay*

9.5.1 Biomass and landings 2007- 2023

Biomass estimates from annual surveys in 2007-2023 are not strictly comparable because of differences in the time of year in which surveys were undertaken (Table 13). 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. The biomass in 2022 decreased by 100 tonnes on the previous year of 2021. The 2023 biomass increased by approximately 800 tonnes on the 2022 biomass. No fishery occurred when the biomass was less than 1,200 tonnes (e.g. 1,032 tonnes in 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 13. Annual biomass, TAC and landings of cockles in Dundalk Bay 2007-2023.

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	810	1,128	1,128	0
2021	June	1,927	406	642	638	0
2022	May	1,826	375	608	0	0
2023	May	2,603	527	867	867	0

9.5.2 Survey in 2023

9.5.2.1 Biomass

A pre-fishery survey was completed in late May 2023. The survey area was 30.5 km^2. Total biomass was 2,603 tonnes (Table 14) based on a geostatistical model. Biomass of cockles over 22 mm was 1,930 tonnes (Figure 45).

Table 14. Biomass of cockles in Dundalk Bay in May 2023.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Biomass All sizes	2,603	2,837	2,552	3,130
Biomass (tonnes) > 22mm	1,930	2,125	1,940	2,302
Biomass (tonnes) > 18mm	2,543	2,745	2,482	3,013
Biomass (tonnes) < 18mm	100	110	92	125

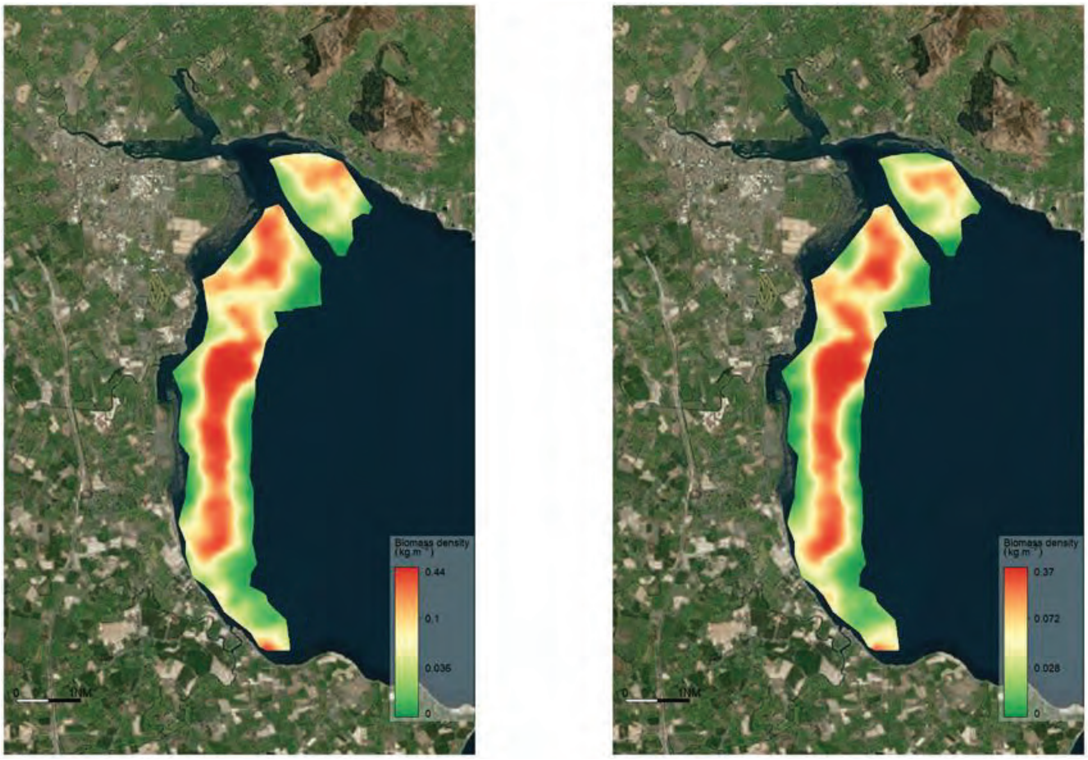


Figure 45. Distribution and density (kgs.m^{-2}) of all cockles (left) and commercial cockles (>22 mm shell width) (right) in Dundalk Bay in May 2023.

9.5.2.2 Size distribution and recruitment

The majority of cockles (86 %) sampled during the 2023 Dundalk cockle survey were estimated to be 0 to 2 years old. The highest percentage of these (48.5 %) were 2+ year olds (see the bottom graph in Figure 46). A smaller cohort can be seen at a modal size of 7.96 mm (Figure 46). The growth of a strong 0+ cohort in 2018 lead to an increase in biomass and landings in 2019 and 2020. However, no significant recruitment (spat settlement) was detected in 2019-2021. Growth of the larger cohort recorded during the 2022 survey (~17 mm) led to the large size cohort in 2023 with a modal size of 20.84 mm.

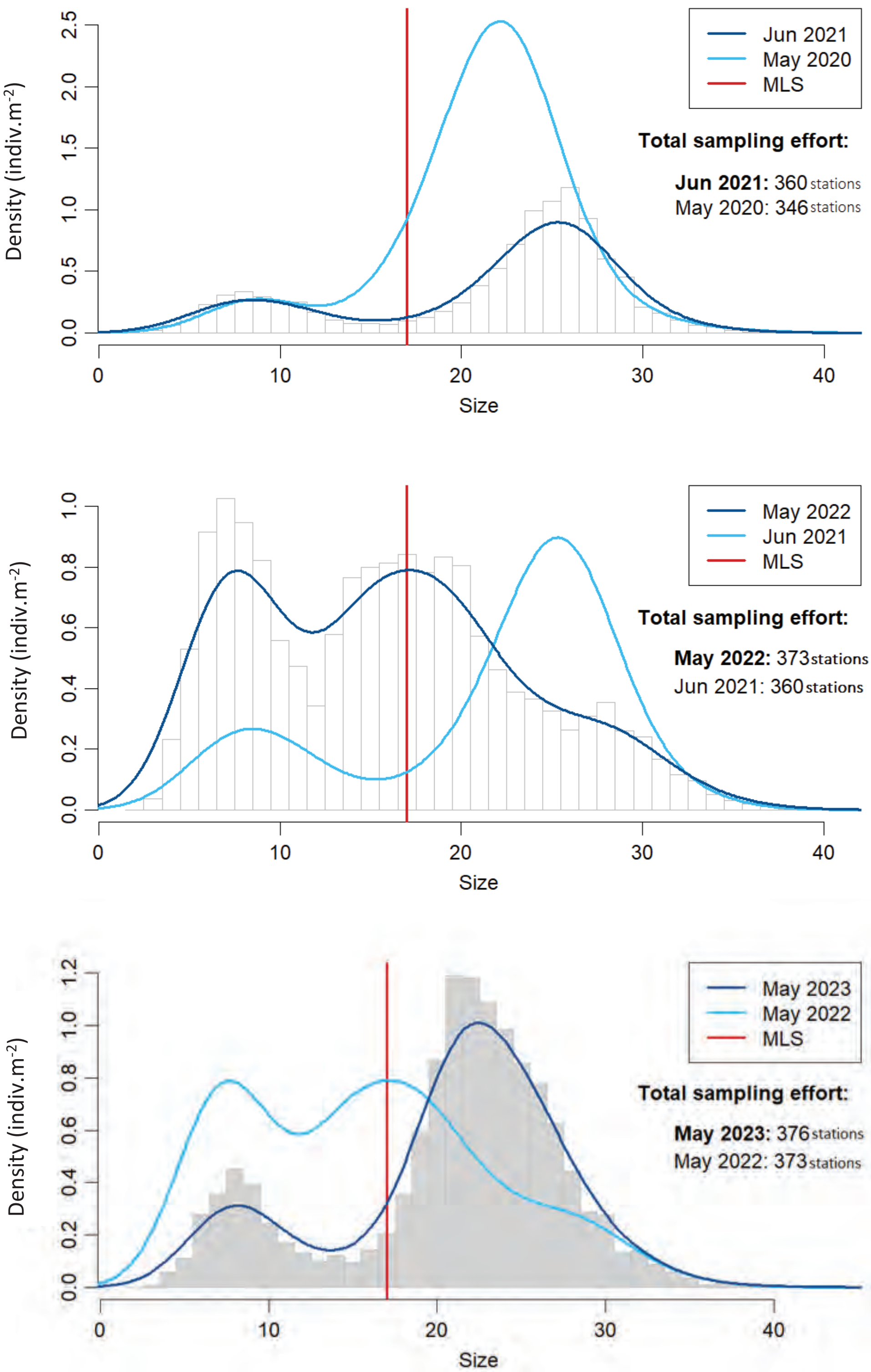


Figure 46. Size distribution of cockles in Dundalk bay in May 2020 and June 2021 (top), June 2021 and May 2022 (middle) and May 2022 and 2023 (bottom).

9.5.3 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 and overwintering water birds are reported here.

9.5.3.1 Intertidal habitats

The three numerically dominant species of bivalve in the intertidal habitat of Dundalk Bay are *Cerastoderma edule* (cockles), *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 *A. 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 more fragile 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 2007-2023. Both *A. tenuis* and *M. balthica* can occur in high densities (Table 15, Figure 47). An increasing trend in average densities, per m^2, of *Angulus tenuis* can be seen from 2018 to 2022 with a decrease recorded 2023. Average densities of *Macoma balthica* per m^2 have declined year on year since 2018, however a slight increase was seen in 2023. The distribution of *Angulus* and *Macoma* from the 2021, 2022 and 2023 cockle surveys is shown in Figure 48.

Average densities of the lugworm, *Arenicola marina* have shown an overall decrease since 2014 when the highest densities of 11.62 m^{-2} were recorded. In 2021, average densities of *A. marina* increased slightly, however a further decrease was recorded during the 2022 and 2023 surveys (Table 15, Figure 47).

Table 15. 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 2011-2023.

Year	*Angulus tenuis*		*Macoma balthica*		*Arenicola marina*		Redox Potential Discontinuity (RPD) layer	
	Mean	S.d.	Mean	S.d.	Mean	S.d.	Mean	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	9.98	7.29
2021	88.27	85.2	14.56	28.73	4.27	3.65	10.44	4.96
2022	101.22	96.55	13.41	30.24	3.43	3.01	10.50	4.07
2023	98.31	97.96	14.27	33.15	3.06	3.04	10.37	5.19

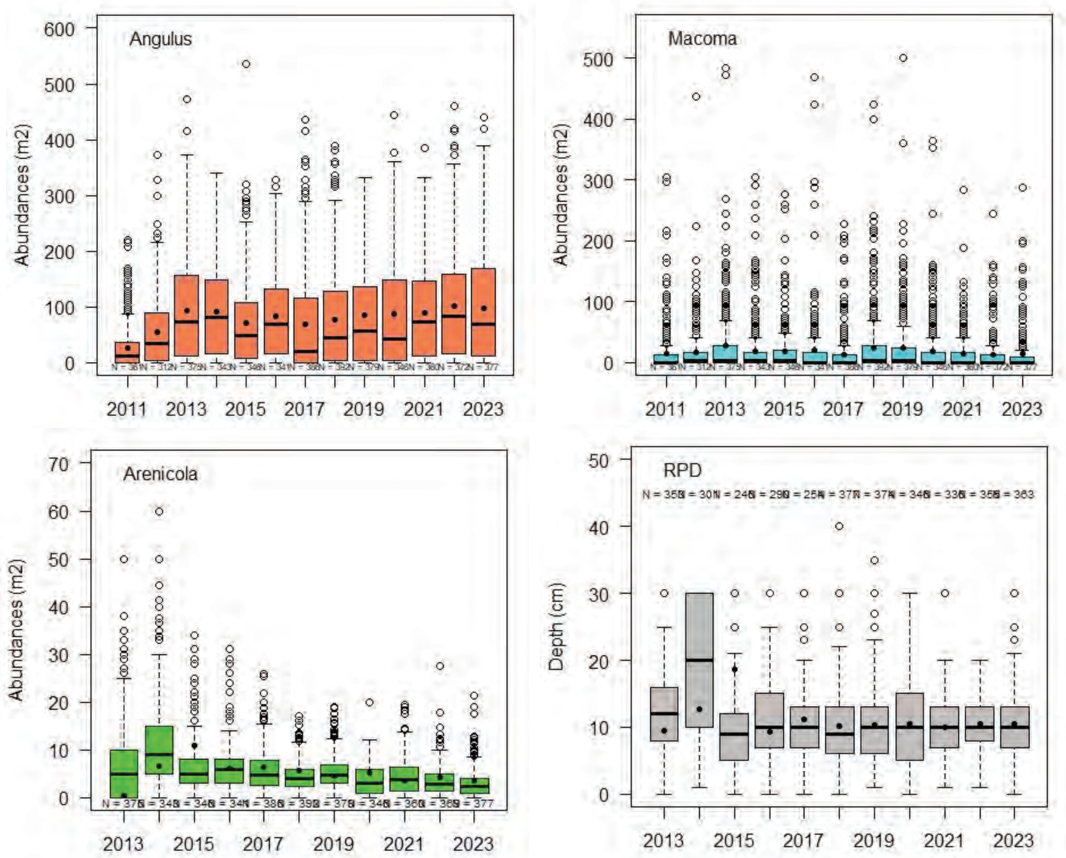


Figure 47. Median abundances (m^2) of *Angulus tenuis*, *Macoma balthica* (2011-2023) and *Arenicola marina* (2013-2023) and median depth of the redox potential discontinuity layer (RPD) (2013-2023) across intertidal sediments in Dundalk Bay. The mean values for each year are indicated by the black dots.

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 2023 (Table 15, Figure 47). It has been consistent at an average depth of about 10 cm since 2015.

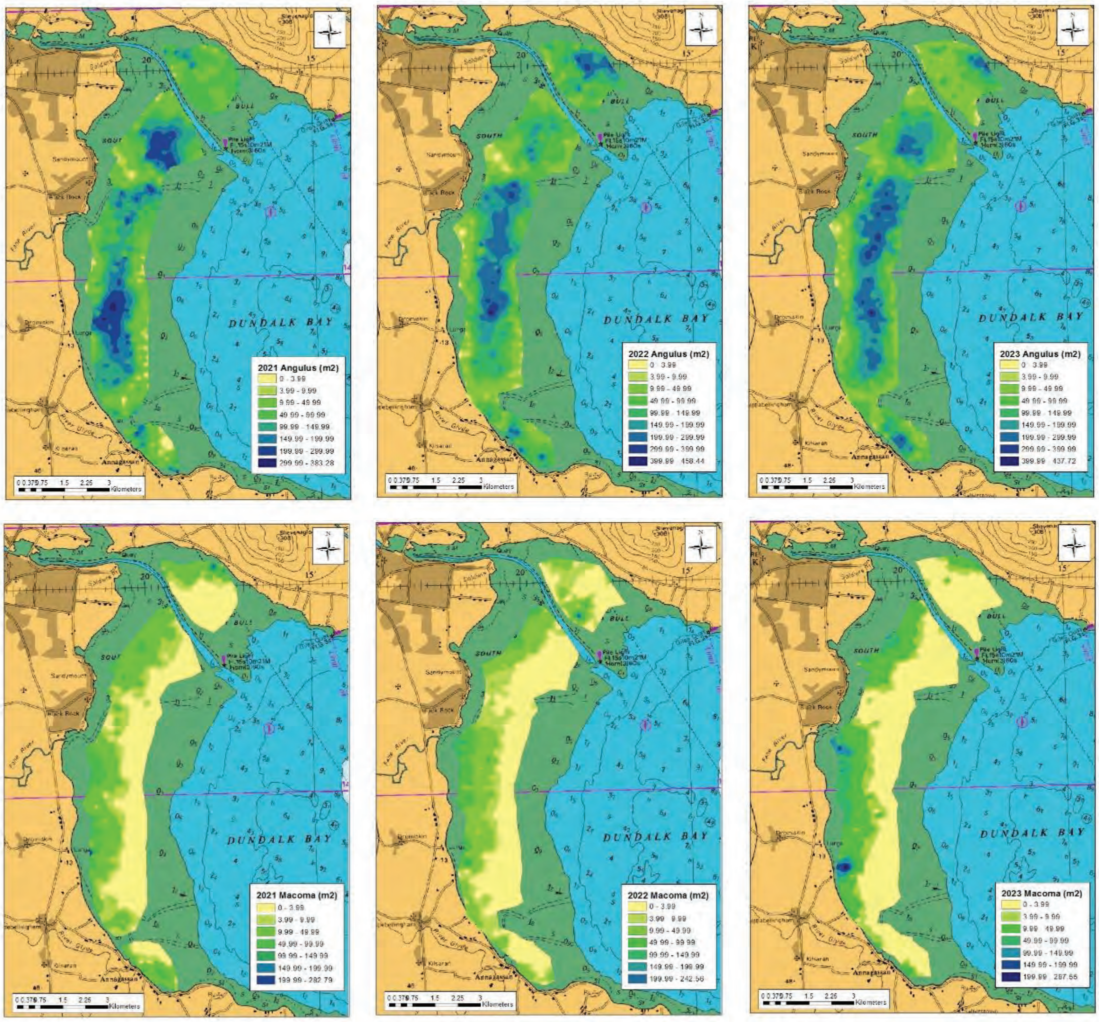


Figure 48. Annual distribution of *Angulus tenuis* (top) and *Macoma balthica* (bottom) during summer surveys undertaken in Dundalk Bay 2021-2023.

9.5.4 Waterbirds

Overwintering birds in Dundalk Bay have been monitored since the mid-1990s by iWeBs (Irish Wetlands Bird Survey). Counts are taken at key roost locations at high tide. Additional low tide counts have been undertaken periodically by the National parks and Wildlife Service and the Marine Institute.

The highest numbers of birds (all species, 61,255) in Dundalk Bay were recorded in winter 2003/2004 (Figure 49). The long term trend (1994-2023) varies but is stable. The 2021/2022 winter season saw the lowest ever recorded total since the beginning of the survey at 21,583. It is difficult to ascertain to what degree the avian influenza or COVID survey restrictions might have affected this number. The 2022/2023 season saw this number increase again to 34,825.

Data for different feeding groups namely Bivalve feeders, Fish feeders, Generalist feeders, Invertebrate feeders and Vegetation feeders show variable patterns (Figure 50). Bivalve feeders declined in 2012/13 and continued to decline up until 2022/2023. Less significant decline was also seen in invertebrate feeding group. Low levels of the fish, generalists and vegetation feeders remain stable.

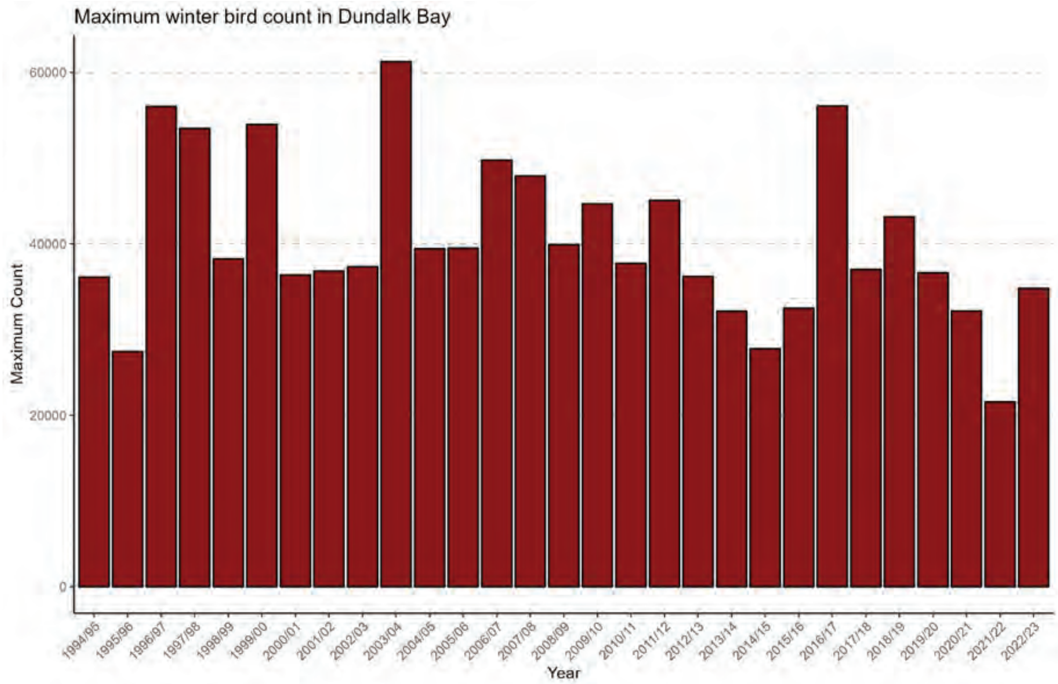


Figure 49. Trends in the number of all bird species from September to February during the winter seasons from 1994/1995 to 2022/2023 in Dundalk Bay.

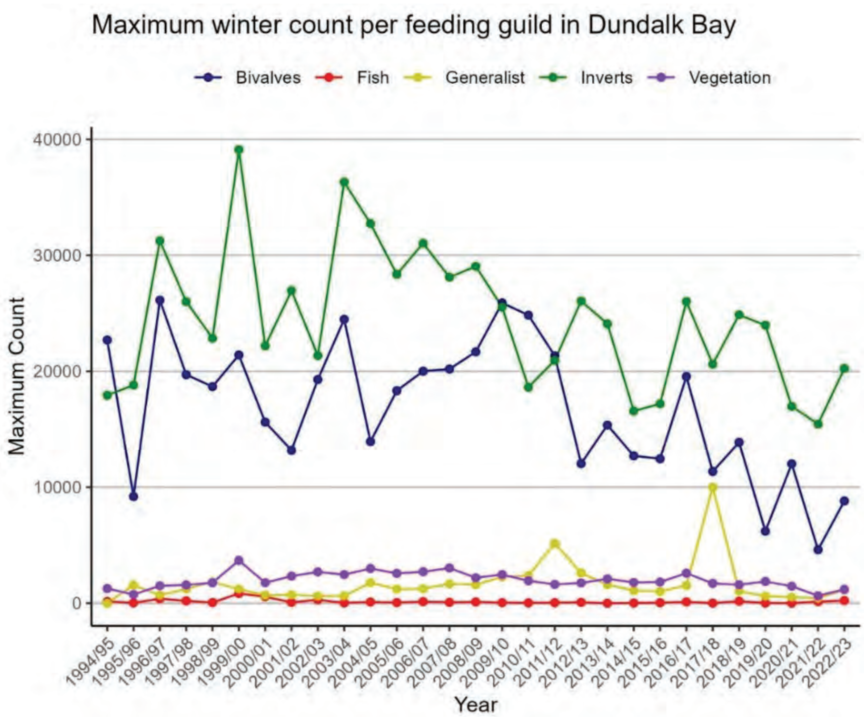


Figure 50. Trends in the number of bird feeding groups from September to February in Dundalk Bay. from 1994/1995 to 2022/2023.

There has been no change in the structure, function or distribution of intertidal habitats which support these bird populations in Dundalk Bay since 2007 and no significant effects of cockle fishing on habitats has been found. Bird populations not relying on cockle as a food source are unlikely to be impacted by the fishery.

9.5.4.1 Oystercatcher

Oystercatcher feed on cockles. However, work contracted previously by the Marine Institute in Dundalk Bay also shows that it feeds on other prey and, in particular, in grasslands bordering Dundalk Bay. NPWS report average maximum counts of 8,746 birds in their reference period 1995/96 to 1999/00. iWeBs counts of over 14,000 oystercatchers in 1999/00 and 2006/2007 were the highest counts in the 29 year time series (Figure 51). Recent 5 year averages and longer term 10 year averages were 5,224 and 5,835 birds, respectively, which represent a decline in the total number of oystercatcher compared to the same averages in 2020. A year on year decline occurred from 2016/17 to 2019/20 and the lowest ever recorded number of oystercatcher was in the 2021/22 winter.

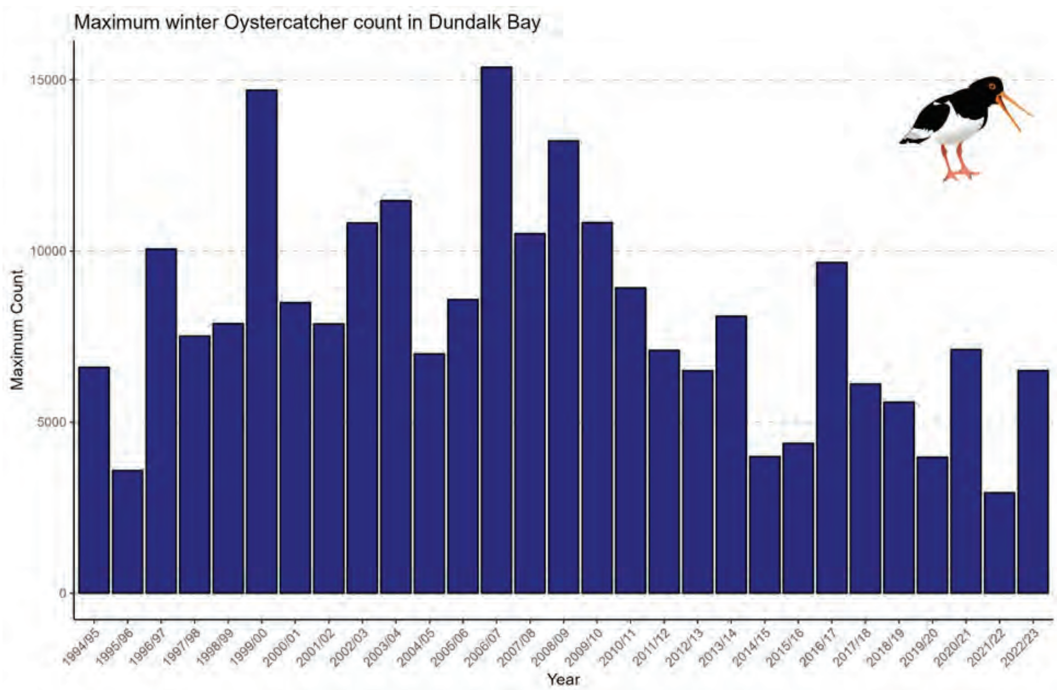


Figure 51. Trends in the number of oystercatcher (*Haematopus ostralegus*) from September-February during the winter seasons from 1994/1995 to 2022/2023 in Dundalk Bay.

The number of oystercatcher at other east coast sites south of Dundalk Bay hold lower numbers of birds than Dundalk Bay (Figure 52). Trends in oystercatcher are stable at most of these sites however they are negative at Boyne estuary and Rogerstown estuary. The year on year variation in counts is much higher in Dundalk than in other sites. Since 2013 the yearly difference from the mean count has been negative in most sites (Figure 53), although the difference is much higher in Dundalk than elsewhere. The number of monthly counts completed in Dundalk Bay in recent winters is low. This may contribute to the high variability in the maximum count index used to show trends over time.

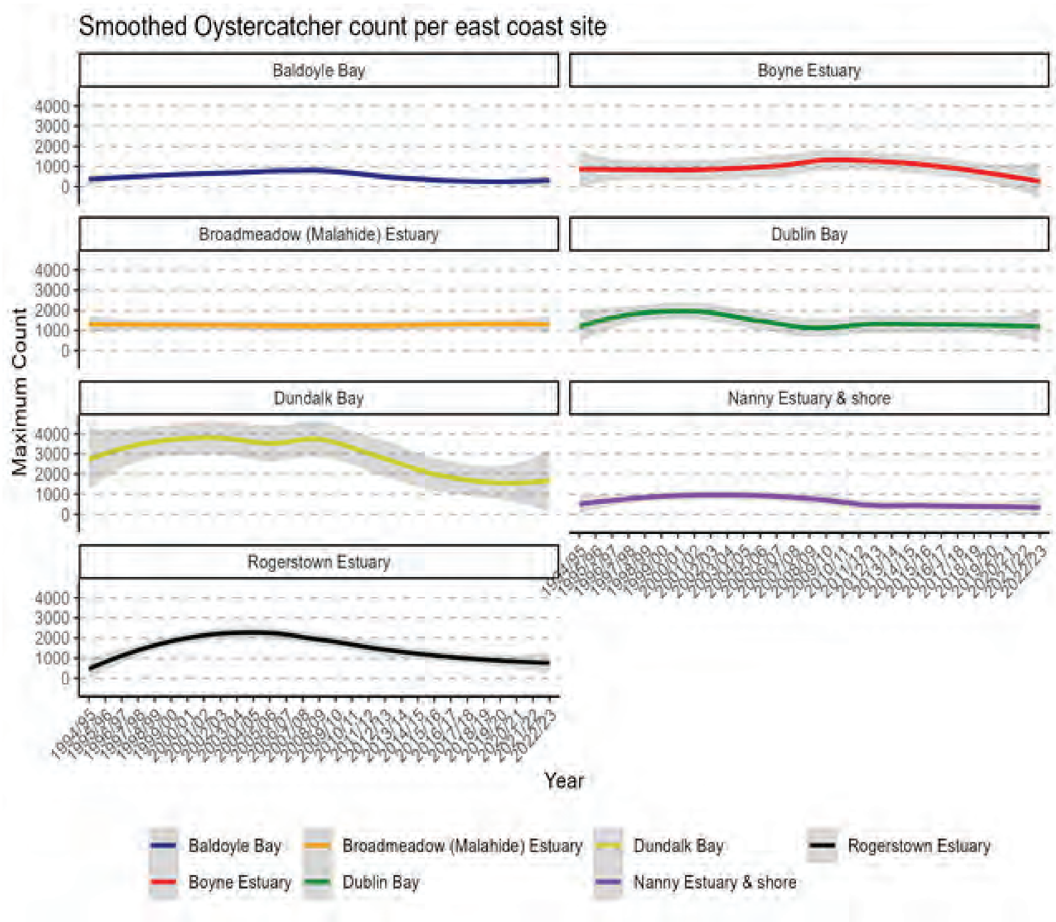


Figure 52. Trends in the number of oystercatcher (*Haematopus ostralegus*) from September-February during the years 1994/95 to 2022/2023 from several wintering sites along the east coast including Dundalk Bay.

The number of oystercatchers overwintering in Dundalk Bay has a slightly positive correlation with the post fishery cockle biomass (Figure 54). This is the biomass that is available in autumn when the fishery is closed. However, the relationship is weak and influenced by single outlying points.

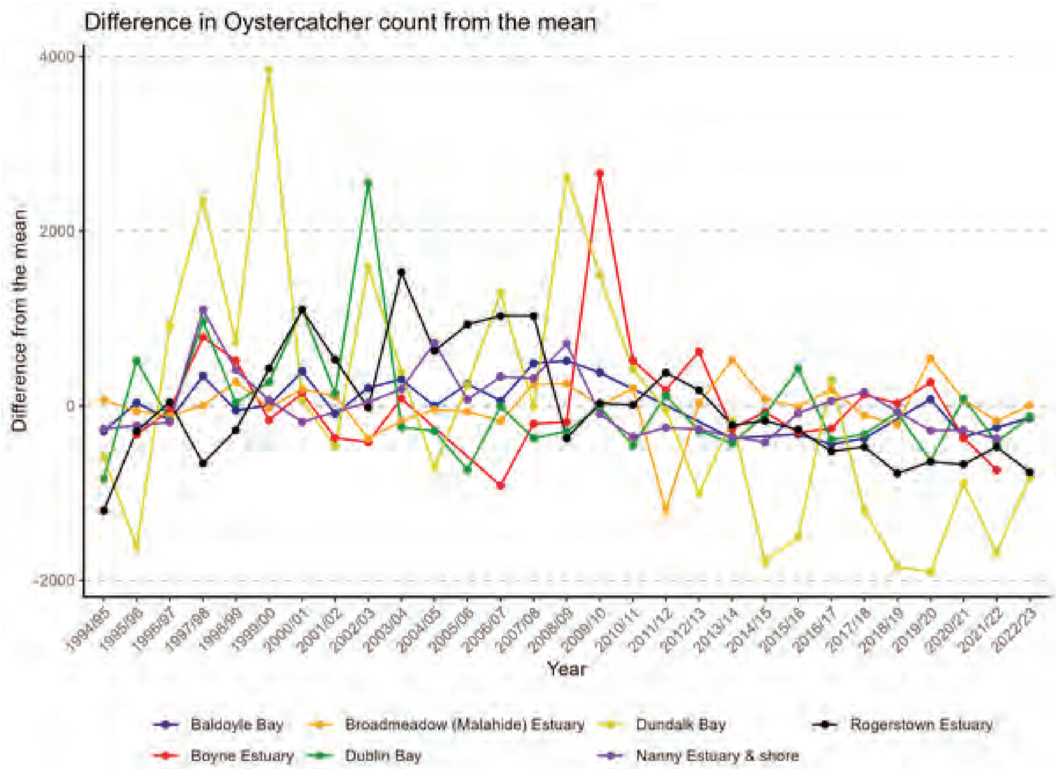


Figure 53. The yearly difference in Oystercatcher (*Haematopus ostralegus*) count from the mean during the years 1994/95 to 2022/2023 from several wintering sites along the east coast including Dundalk Bay.

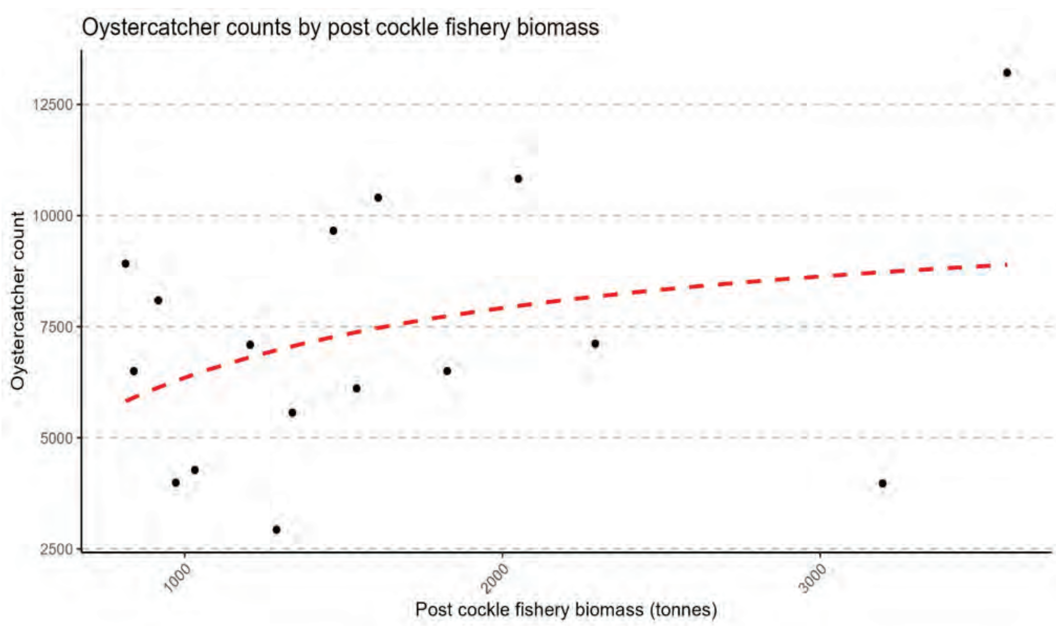


Figure 54. Relationship between oystercatcher (*Haematopus ostralegus*) numbers (iWeBs data) and post fishery cockle biomass in Dundalk Bay 2007-2023. The fitted curve is a Beverton and Holt stock (cockle) and recruitment (oystercatcher) function R=aS/(b+S), a = 10519 (the asymptote of the curve) and b = 655 (steepness) or the cockle biomass required to recruit 0.5 of the asymptotic value.

10 Mussels (Mytilus edulis)

10.1 *Management advice*

Mussels are fished for relay and ongrowing in inner Dingle Bay and in the south Irish Sea. Mussel fishing in these areas is managed mainly under Fishery Natura Plans implemented through Fishery Natura Declarations. Fishing for mussels in other areas, which are mainly intertidal, but also subtidal in an area of Wicklow Reef and Dalkey sound SACs, is prohibited.

The harvest strategy for mussel does not limit the exploitation rate. This strategy is based on the premise that seed mussel beds are ephemeral and do not significantly contribute to larval production or recruitment. The natural mortality rate of mussel beds due to predation and exposure to wave action and scouring is, however, variable and additional data on the pattern of mortality in space and time is needed to inform the strategy.

Common scoter, a species of diving seaduck that feeds on bivalves, overwinters in shallow waters of the south Irish Sea where habitat is suitable for benthic foraging. The species is of special conservation interest in the Raven SPA and in the Seas off Wexford SPA. Following appropriate assessment (*sensu* Article 6 of the Habitats Directive) of the potential effects of mussel fishing on common scoter an area was closed to fishing in 2023 to protect overwintering foraging habitat for scoter. The spatial and temporal overlap between scoter and seed mussel beds are being investigated further, using aerial seabird surveys, to determine the efficacy of the spatial conservation measure introduced in 2023.

10.2 *Issues relevant to the assessment of the mussel fishery*

Annual recruitment to mussel stocks (beds) in the Irish Sea and inner Dingle Bay is variable. Locating new settlement in the Irish Sea is difficult as its timing and location can vary and the spatial extent of the beds are usually relatively small. BIM undertake annual surveys in the Irish Sea, using side scan sonar techniques, to locate mussel beds. Many of the beds are dominated by seed mussel and biomass changes rapidly due to growth and mortality. Even short term forecasting of biomass that might be available to the fishery at any point in time is difficult in these cases. Age and biomass progression of mussel beds varies; some beds are dominated by recent settlement only while other beds may have mixed age groups depending on the previous level of mortality experienced by these cohorts during their development and especially overwinter. Defining a harvest strategy for mussel, especially where natural mortality may be high but variable is difficult.

Many of the seed mussel fisheries operate within or close to Natura 2000 sites. The fishery in inner Dingle Bay, the relay operations in Castlemaine Harbour and the fishery in the Irish Sea are under Natura 2000 fisheries management regimes. Five year Fishery Natura Plans (FNPs) are implemented through Fishery Natura Declarations (FNDs) which are legal instruments that ensure the fishery is consistent with conservation objectives for habitats and species designated in Natura sites.

The main management issues relate to the harvest strategy for seed mussel beds, the ecosystem effects of that harvest especially on Natura features, the ecological importance of mussel beds generally and the effects of the relay of mussel seed into aquaculture sites or fishery order areas on habitat and species.

10.3 *Management Units*

Mussels are ubiquitous around the Irish coast. Stock structure is likely to be determined by the scale of larval dispersal as effected through hydrodynamic regimes. Stocks in the south Irish Sea (off Wicklow and Wexford) may effectively, from a management perspective, be separate to those of the north Irish Sea given the very different hydrodynamics in these two areas. There may be local self-recruiting stocks in Bays where larval retention is high. Inner Dingle Bay and Castlemaine Harbour can be regarded as a separate assessment and management unit.

10.4 *Management measures*

Mussel fishing is prohibited in intertidal habitats (FND 3/2018). Mussel fishing is excluded from Dalkey Sound (FND 2/2019) and is restricted in Wicklow reef SAC (FND 3/2018). Based on an appropriate assessment in 2023 fishing is prohibited in an area off east Wexford (FND 3/2023) to protect wintering foraging habitat for Common Scoter. The rationale for this recent measure is described below.

Mussel seed (quota) is allocated to individual vessel owners annually. Fishing is allowed only for defined periods of time, usually Autumn, during the year. Fishing is permitted at tides <7.1m on Llanelli tide tables. A minimum of 1,500 tonnes of seed has to be available, as estimated from surveys, before the fishery opens. This, however, does not operate as a limit reference point given that the biomass may be reduced to well below 1,500 tonnes under the harvest strategy which does not limit the harvest rate.

10.5 *Catches for relay*

Catch of mussel for relay declined from 12,000 tonnes to 2,500 tonnes during the period 2010-2013 and, with the exception of 2018, recovered to 8,000-10,000 tonnes in the period 2014-2020. Catch for relay in 2020 was 8,921 tonnes and was similar to years 2014-2019 other than 2018 when catches and BIM survey estimates were both low (Figure 55). With the exception of 2017, there is good correlation between the catch data and the survey estimates although the catch is generally higher than the survey biomass estimates each year. The outtake in 2021 of 9,270 tonnes (source: DAFM) was remarkably close to the survey estimates in 2021 of 9,293 tonnes. In 2022 total biomass was estimated at 9,384 tonnes. BIM surveys in 2023 reported very low recruitment of mussels. The fishery did not open in 2023.

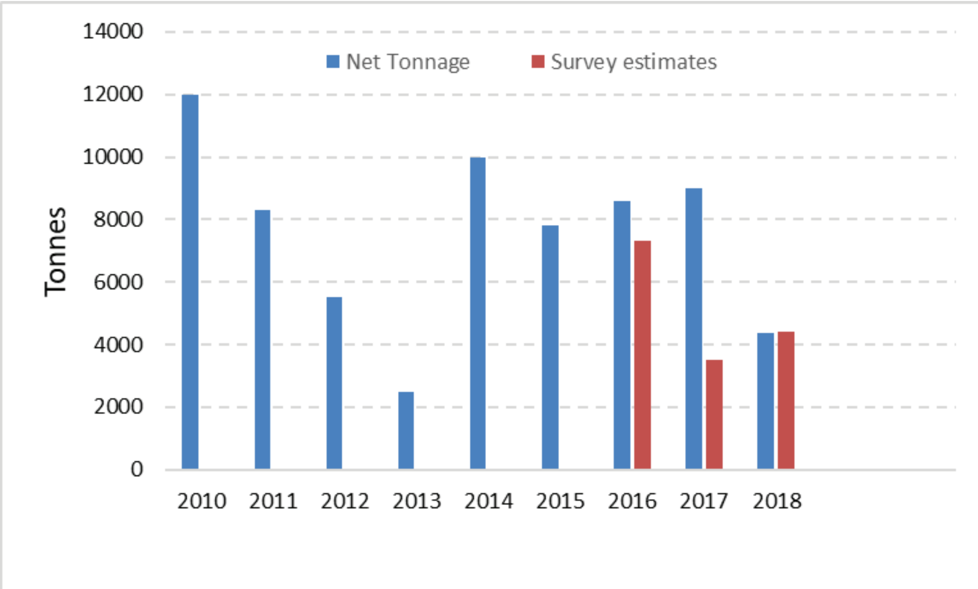


Figure 55. Landings (for relay) of seed mussel by vessels registered in the Republic of Ireland 2010-2018 and corresponding estimates of biomass from BIM surveys. Source: BIM and SFPA.

10.6 *Assessment of effects of mussel fishing on diving seaducks (Common Scoter)*

Aerial seabird survey data from 2014 and 2020 show that common scoter are distributed within and in proximity to Dundalk Bay SPA, south along the coast of Meath and along the east coast of Wexford, including in the Raven SPA, during winter months. Seed mussel beds and fishing have historically been present off the east coast of Wexford where foraging conditions for common scoter are highly suitable. Mussel may make up a large portion (60 %) of the common scoter diet to the extent that common scoter, in the North Sea, are 'mussel specialists'. Optimal foraging conditions and suitable foraging habitat for common scoter are shallow waters (ideally less than 20 m depths but with scope to dive to 30 m) and with water column current speed of less than 0.6 m/s [1]. The characteristics of essential habitat for common scoter are, therefore, easy to define; shallow areas with weak currents and with bivalve beds in or on the seabed.

A habitat suitability index for common scoter estimated from depth and the proportion of time currents are <0.6m.sec^{-1} (from Marine Institute ocean model estimates) shows that waters along the east Wexford coast are suitable habitat for scoter. These areas also contain mussel beds.

A habitat suitability index for common scoter estimated from depth and the proportion of time currents are <0.6m.sec^{-1} (from Marine Institute ocean model estimates) shows that waters along the east Wexford coast are suitable habitat for scoter. These areas also contain mussel beds.

[1] Breen P, Clarke S, Tully O (2022) Modelling essential habitat for common scoter (Melanitta nigra) in a disturbed environment. Estuarine, Coastal and Shelf Science 276:108007.
Kaiser MJ, Galanidi M, Showler DA, Elliott AJ, Caldow RWG, Rees EIS, Stillman RA, Sutherland WJ (2006) Distribution and behaviour of Common Scoter Melanitta nigra relative to prey resources and environmental parameters. Ibis 148:110–128.

An individual common scoter consumes approximately 690 g live weight of bivalves per day. This is an approximate number which does not account for the energetics required to search for prey which will vary by bird, season, habitat suitability and prey density among other factors however, it is considered a useful baseline in the absence of a more sophisticated energetics model.

Aerial surveys conducted by the Marine Institute provide estimates of population abundance of common scoter in the region from Rosslare north to the Wicklow coast to be approximately 5,000 individual birds. Common scoter are present in the south Irish Sea mainly from the beginning of December to the end of February or for 90 days in total. The total potential consumption of bivalves during these months by common scoter is therefore 310.5 tonnes. To successfully forage and consume this biomass significantly higher biomass of mussel would need to be available as energetically it would not be possible to forage for a depleting resource as the foraging season progressed. Conservation of mussel biomass to ensure adequate food resource for common scoter should therefore ensure that multiples of this biomass is retained. Various areas could be closed to fishing to protect common scoter foraging requirements (Figure 56). The biomass of mussel, from BIM surveys, within each of 3 possible protected areas was estimated based, pro-rata, on the proportion of the survey area that was within each of the areas. This analysis showed a suitable option would be to close a relatively small area of the east Wexford coast to protect the foraging requirements of scoter (right hand panel Figure 57). This area held significantly more seed mussel than the 310.5 tonnes foraging requirement in both 2021 and 2022. This mitigation is likely to be sufficient if mussels are persistently present within the proposed closed area. If that is not the case the closed area may need to be reviewed periodically based on mussel survey data. The closure was implemented through FND 3/2023.

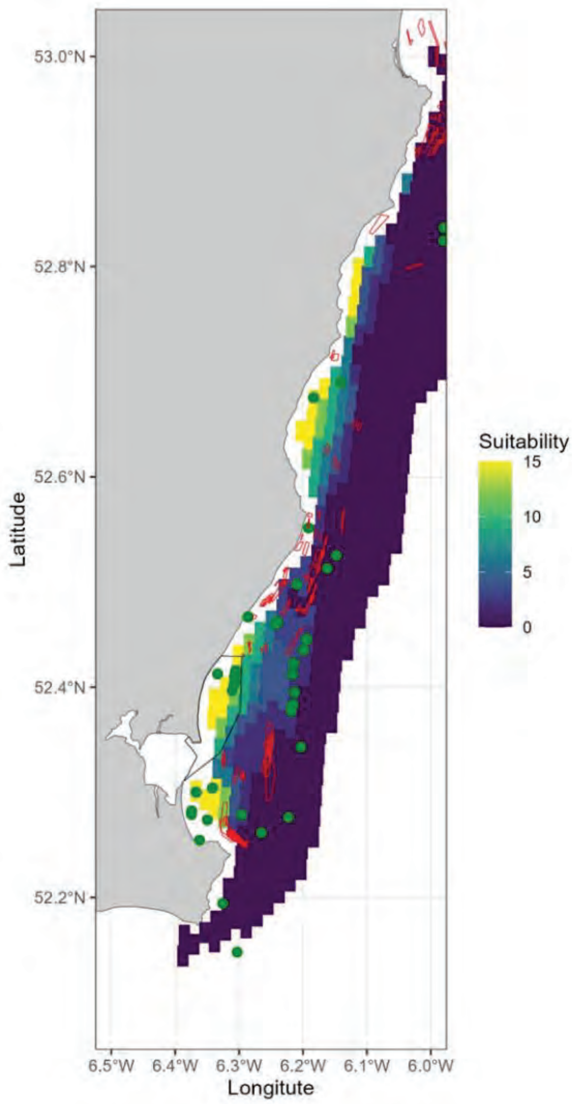


Figure 56. Foraging habitat suitability index for common scoter in the south Irish Sea. The Raven SPA is outlined. Red polygons are BIM seed mussel surveys. Green dots are common scoter sightings from aerial surveys.

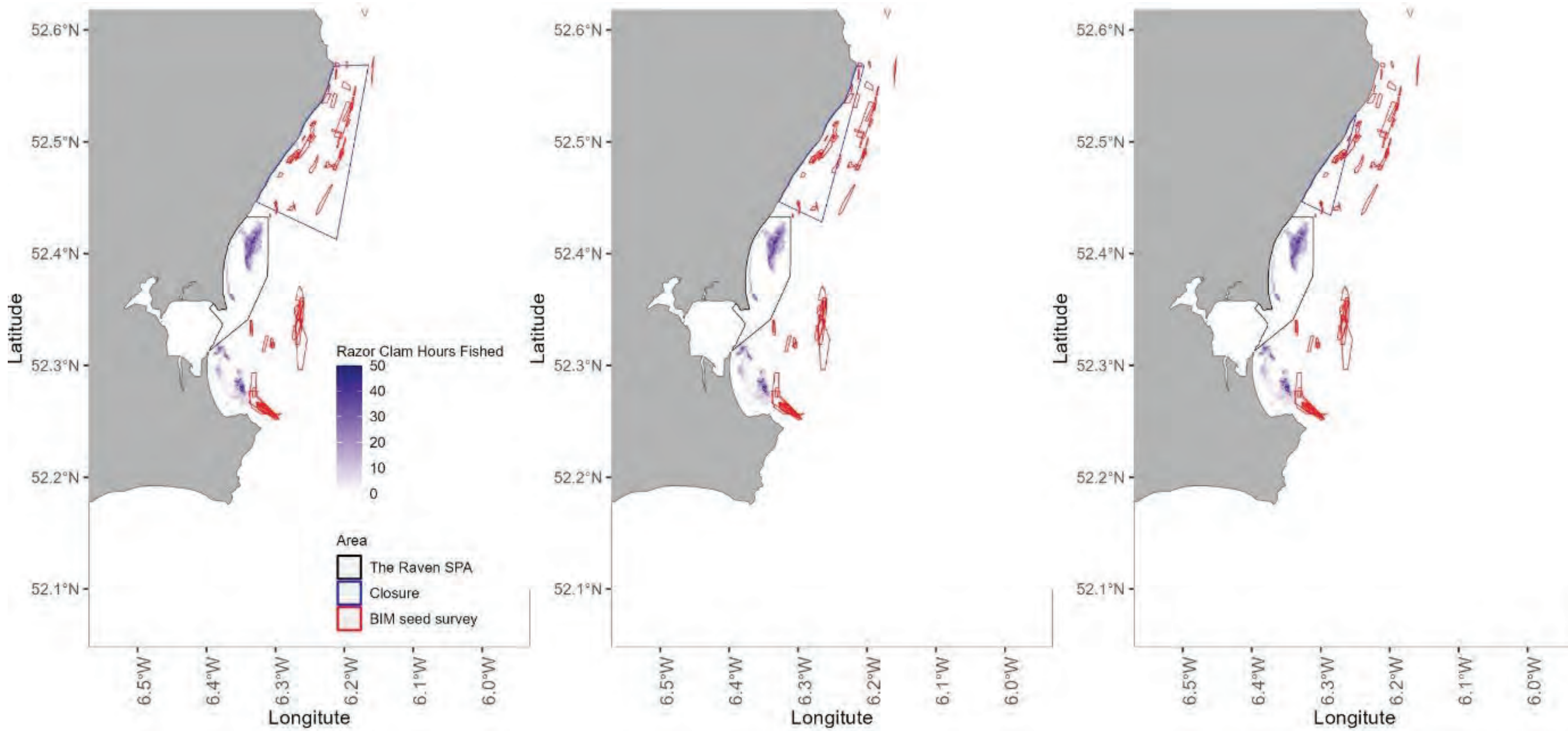


Figure 57. Mitigation options based on habitat suitability, presence of seed mussel beds and the feeding requirements of common scoter. Left all suitable option, middle, very suitable option and right the most suitable. The options for the closed area (the northern most polygon on the maps) are progressively smaller from left to right.

11 Oyster (*Ostrea edulis*)

11.1 *Management advice*

With some exceptions oyster stocks are managed locally by oyster Co-operatives who have delegated authority to manage oysters in specific areas through fishery orders or aquaculture licences. Minimum sizes of 76-78 mm apply. Local quotas or TACs may be in force. The number of dredge permits issued annually is limited.

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 include naturalisation of Pacific oyster (*Magallana gigas*), *Bonamia ostreae* infection, poor water quality, unfavourable habitat conditions for settlement and low spawning stocks. Pacific oyster has naturalised in Lough Swilly in recent years and supports a commercial fishery.

Generally, although seasonal quotas and minimum size regulations are in place for some fisheries, fishery management plans and oyster restoration plans should be developed in order to restore productivity of oyster beds. A range of actions should be considered including closing areas to fishing where spawning stock and habitat complexity could be re-built, removal of Pacific oysters, maintenance or restoration of habitat for settlement, development of harvest control rules for the fishery and improving operational management locally.

Oyster beds are constituents of habitats designated under the Habitats Directive in many areas. Specific conservation objectives have been defined for these habitats in some sites. Oyster beds are listed as a key feature for restoration in the EU Nature restoration regulation.

11.2 *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 from year to year. 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 ostreae* 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. Since 2022, new management plans have been drafted with some of the oyster co-operatives in order to secure any improvements in stock status resulting from restoration actions and to ensure adequate conservation of spawning stock and spawning potential in areas closed to fishing. These plans, and the objectives and strategies described in them, have become the focus of monitoring, research and management initiatives.

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 maërl 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.

11.3 *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 and Beirteach Buí in Connemara, Clew Bay, Blacksod Bay and Lough Swilly.

11.4 *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.

11.5 *Inner Tralee Bay*

11.5.1 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 16). 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 corrected for dredge efficiency has varied from just over 600 tonnes to over 1,000 tonnes.

Table 16. Stock biomass trends for native oyster in Inner Tralee Bay 2010-2023.

Year	Month of survey	Survey Area (km^2)	Biomass	Biomass km^{-2}
2010	September	4.26	982	230.54
2011	September	3.57	631	87.03
2012	February	3.8	655	85.02
2013	September	3.76	506	66.33
2014	September	3.8	1,265	164.16
2015	September	4.51	409	44.78
2016	September	3.66	901	121.44
2017	September	4.28	843	197.08
2018	September	3.92	1,161	296.17
2019	October	3.7	879	237.57
2020	September	5.32	1,618	304.14
2021	September	4.05	617	152.35
2022	September	4.55	801	176.04
2023	September	4.49	891	198.44

11.5.2 Survey September 2023

A pre fishery survey was carried out on the 11-12th September 2023 in Inner Tralee Bay. A total of 76 tows were completed, 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 the swept area for each tow was estimated. The survey encompassed an area of 4.49 km^2 east of Fenit pier (Figure 58).

11.5.2.1 Distribution and Biomass in 2023

Biomass of oysters uncorrected for dredge efficiency varied from 0-0.38 $kgs.m^{-2}$ (Figure 58). Biomass of oysters over 76 mm ranged from 0-0.11 $kgs.m^{-2}$.

Total biomass of oysters, assuming a dredge efficiency of 35 %, was 891 tonnes (Table 17). The equivalent biomass of oysters 76 mm or over was 331 tonnes or approximately 37 % of the total biomass.

Table 17. Distribution of oyster biomass in Inner Tralee Bay in September 2023.

	Mean	Median	95% HDI inf	95% HDI sup
Uncorrected for efficiency				
Biomass_Ostrea_edulis	311.73	332.67	284.61	381.04
Biomass_>76mm_Ostrea_edulis	111.66	135.19	111.17	160.15
Corrected_35% Dredge Efficiency				
Biomass_Ostrea_edulis	890.67	951.89	827.69	1,099.15
Biomass_76_Inf_Ostrea_edulis	331.52	390.70	322.98	455.17

Figure 58. Distribution and biomass of native oyster in Inner Tralee Bay from the September 2023 survey (uncorrected for dredge efficiency).

11.5.2.2 Size distribution 2023

The size distribution of oysters caught during the survey showed a strong mode at 71 mm, slightly smaller than the predominant mode of 75 mm in 2022. There was a weak signal of this years' settlement at about 10 mm. Two smaller modes were also visible at 31 mm and 41 mm (Figure 59).

Future prospects for the stock remain strong given that all size classes from 60-78 mm are well represented in the stock. Mortality rates on oysters below 78 mm appear to be low.

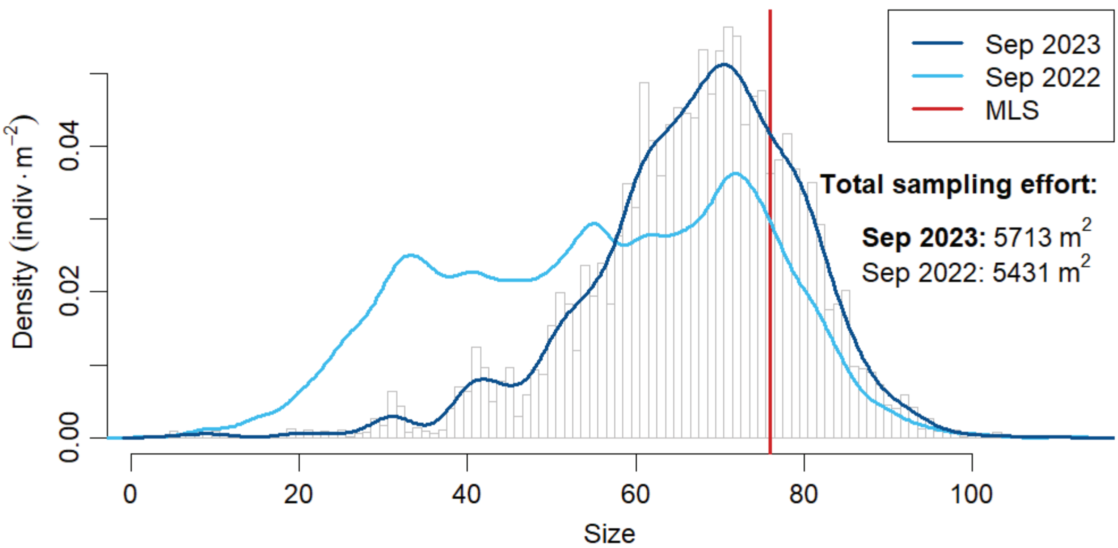


Figure 59. Size distribution of native oysters on the Inner Tralee oyster bed in September 2023. The MLS (76 mm) is also shown. Data are standardised to sampling effort regardless of its spatial distribution.

11.6 *Galway Bay*

11.6.1 Stock trends

The first survey of the Inner Galway Bay oyster beds was in April 2011. Surveys have continued annually where possible since then (Table 18). The area surveyed for oysters has varied over the years however, with the main bed located between Eddy Island and Rincarna Bay being surveyed most frequently. Oyster biomass in inner Galway Bay has declined in recent years, despite the closure of the fishery since 2017. High mortality rates of oysters over 60 mm is evident in the survey data which is unrelated to fishing mortality.

Table 18. Stock biomass trends for native oyster in Inner Galway Bay 2011-2023.

Year	Month	Survey Area (km^2)	Biomass	Biomass km^{-2}
2011	April	2.46	34.56	14.05
2012	February	1.17	28.69	24.52
2012	November	1.11	55.25	49.77
2013	November	1.02	43.8	42.94
2014	November	0.91	59.26	65.12
2016	March	0.73	78.00	106.85
2017	November	0.71	105.5	148.59
2018	October/November	0.72	70.4	97.78
2019	October/September	0.97	8.53	8.79
2021/2022	November/January	2.3	136.6	59.39
2023	October	3.3	90.7	27.48

11.6.2 Survey October 2023

A survey was carried out on 9th and 12th October 2023 on the inner Galway Bay oyster beds (Rincarna and St George's beds). A total of 101 tows were undertaken with a dredge with teeth of width 1.2 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 a combined area of 3.3 km^2 with a total sampling effort of 6,675 m^2 (Figure 60). A dredge efficiency co-efficient of 35 % was applied to assessment outputs, calculated as the average of various dredge efficiency studies previously undertaken in oyster beds around Ireland.

11.6.2.1 Distribution and Biomass in 2023

Biomass of oysters, uncorrected for dredge efficiency, varied from 0-0.0046-0.064 $kgs.m^{-2}$ (Figure 60). These estimates were higher in the north part of the study region. Biomass of oysters over 76 mm ranged from 0.000013-0.002 $kgs.m^{-2}$ and again, showed higher densities in the northern beds.

Total biomass of oysters, assuming a dredge efficiency of 35 %, was 90.7 tonnes (Table 19). The equivalent biomass of oysters 76 mm or over was 2.4 tonnes (Table 19) or approximately 2.6 % of the total biomass. These estimates exclude oysters that settled on scallop cultch after it was deployed in 2021 in the south part of the survey area (see below case study on restoration).

Table 19. Distribution of oyster biomass, corrected for a dredge efficiency of 35 %, in Inner Galway Bay in October 2023.

	Mean	Median	95% HDI inf	95% HDI sup
Uncorrected for Dredge Efficiency				
Biomass_Ostrea_edulis	31.75	45.23	35.85	55.6
Biomass_>76mm_Ostrea_edulis	0.56	0.65	0.55	0.76
Corrected_35% Dredge Efficiency				
Biomass_Ostrea_edulis	90.7	129.2	101.6	159.8
Biomass_>76mm_Ostrea_edulis	2.4	2.62	2.3	2.99

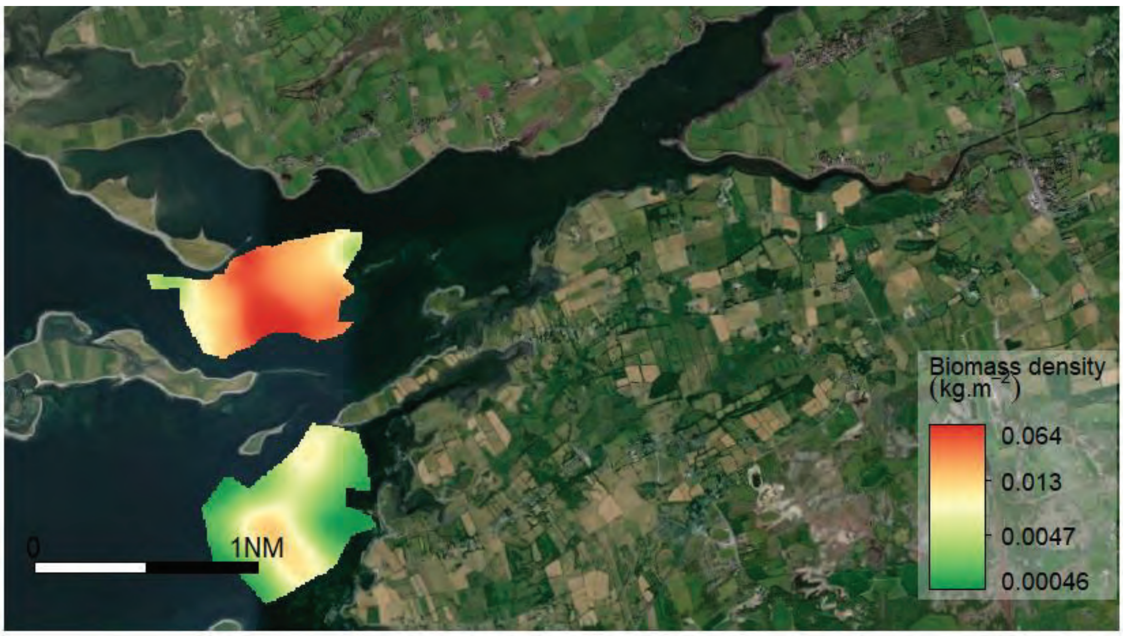


Figure 60. Distribution and biomass of native oyster in Inner Galway Bay in October 2023 (uncorrected for dredge efficiency).

11.6.2.2 Size distribution

The size distribution of oysters caught during the survey showed a strong mode at ~32 mm (Figure 61). Few individuals above the 76 mm minimum landing size were found, but there is an increase in density of over 76 mm oysters compared with the previous survey. No strong indication of recruitment (spat) was observed.

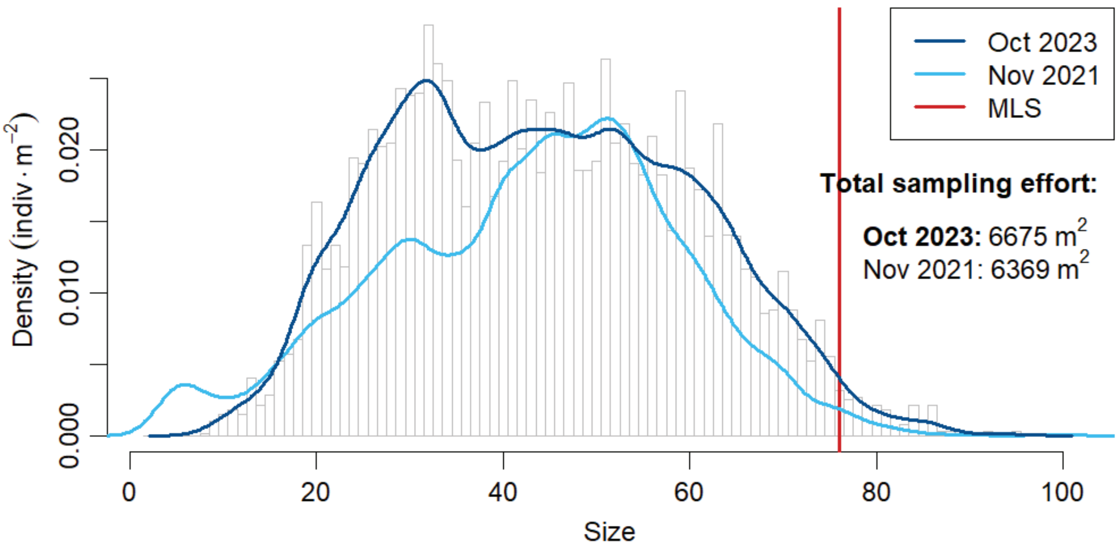


Figure 61. Size distribution of native oysters on the Inner Galway Bay oyster bed in October 2023. The MLS (76 mm) is also shown. Data are standardised to sampling effort regardless of its spatial distribution.

11.7 *Cill Chiaráin Bay*

11.7.1 Stock trends

Surveys have been conducted intermittently in Cill Chiaráin Bay by the Marine Institute since 2010 (Table 20). Prior to 2010, Taighde Mara Teo and Bord Iascaigh Mhara carried out surveys in 2002, 2003 and 2006. Historically the oyster beds in Cill Chiaráin provided a steady return of 50+ tonnes of native oyster per annum for much of the 1990s and in 1998 120 tonnes were landed. Some habitat management (cultching) occurred at that time but ceased in 1998.

Table 20. Stocks biomass trends for native oyster in Cill Chiaráin 2010-2023.

Year	Month	Survey Area (km^2)	Biomass	Biomass km^{-2}
2010-2011	October/January	2.51	76.81	30.6
2012	October	1.06	13.68	12.9
2018	October	2.36	121.09	51.3
2019	October	1.78	69.2	38.9
2020	October	2.86	138.07	48.3
2021	October	2.00	20.02	10.01
2023	November/December	2.63	32.27	12.27

11.7.2 Survey November/December 2023

A survey was carried out on 28th November and 5th December 2023 in Cill Chiaráin Bay. A total of 145 valid tows were undertaken with a dredge with teeth of width 1.22 m. GPS data for each tow line was recorded on a Trimble GPS survey unit and the swept area for each tow was estimated. The survey encompassed a combined area of 2.63 km^2 with a total sampling effort of 8,503 m^2.

11.7.2.1 Distribution and Biomass in 2023

Biomass of oysters uncorrected for dredge efficiency varied from 0-0.054 $kgs.m^{-2}$, with the highest biomass of oysters concentrated in the central beds of the survey area (Figure 62). Biomass of oysters over 76 mm ranged from 0-0.000089 $kgs.m^{-2}$ and had a similar distribution pattern.

The biomass of oysters, assuming a dredge efficiency of 35 %, in 2023 was 32 tonnes (Table 21). The equivalent biomass of oysters 76 mm or over the national minimum landing size was 0.2 tonnes or 0.62 % of the stock (Table 21).

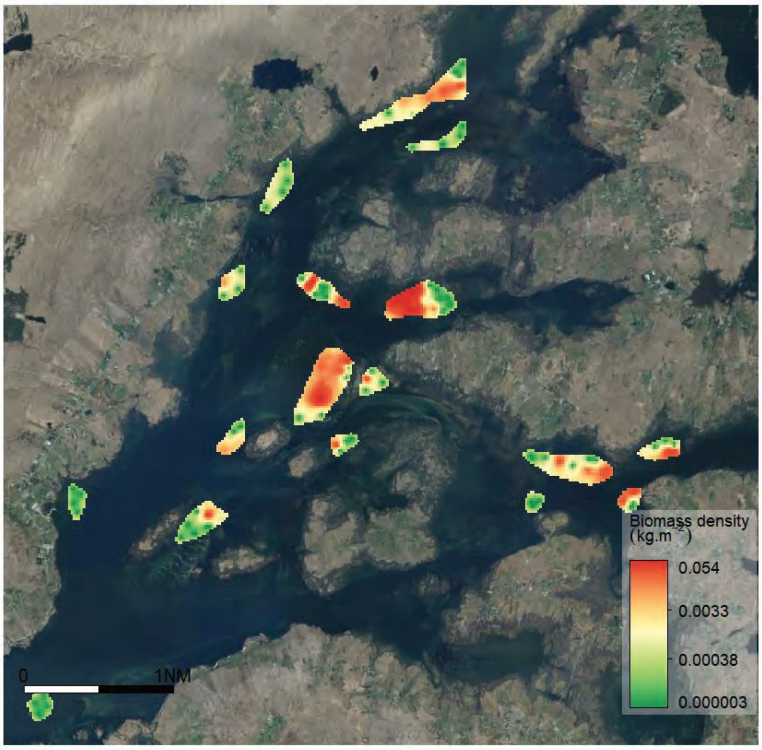


Figure 62. Distribution and biomass of native oyster in Cill Chiaráin in October 2023 (uncorrected for dredge efficiency).

Table 21. Biomass of native oyster in Cill Chiaráin in November/December 2023 based on a dredge efficiency of 35%.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_Ostrea_edulis	10.79	12.45	10.22	14.74
Biomass_>76mm_*Ostrea_edulis*	0.075	0.076	0.071	0.081
Corrected for 35% Dredge Efficiency				
Biomass_Ostrea_edulis	32.27	35.81	30.03	42.05
Biomass_>76mm_*Ostrea_edulis*	0.21	0.21	0.2	0.23

11.7.2.2 Size Distribution

The size distribution of native oysters caught during the 2023 survey shows a single mode at approximately 55 mm (Figure 63). This is similar to the first peak in the 2021 size distribution. The number of oysters greater than the MLS is very low and there is no evidence of recruitment.

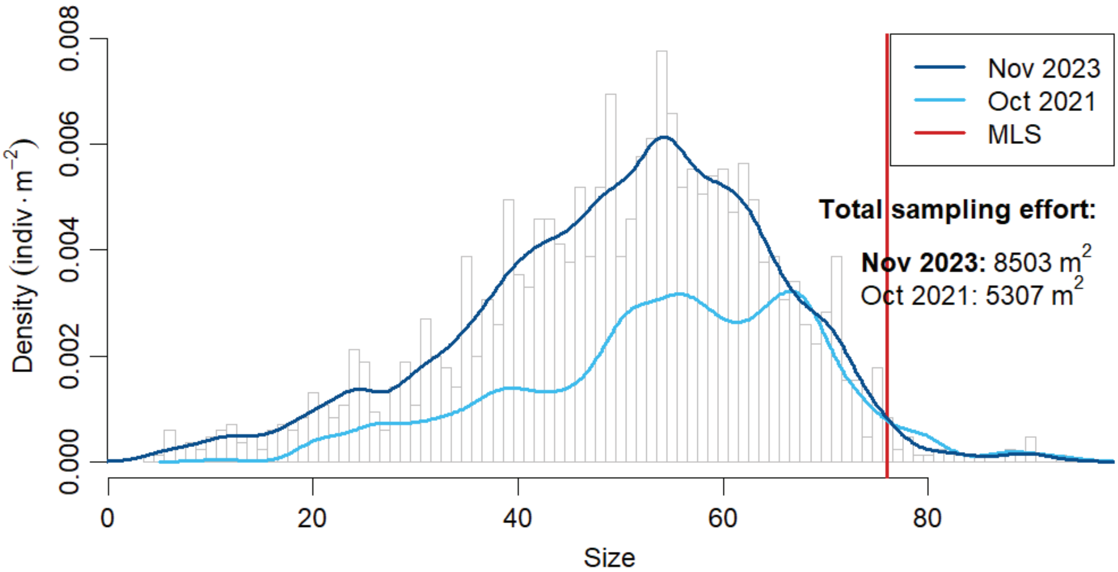


Figure 63. Size distribution of native oysters (*Ostrea edulis*) in Cill Chiaráin in October 2021 and November/December 2023. The minimum landing size (76 mm) is shown. Data are standardised to sampling effort regardless of its spatial distribution.

11.8 *Clew Bay*

11.8.1 Stock trends

Surveys to estimate biomass, distribution and size structure of oysters in Clew Bay were undertaken by the Marine Institute in 2011 and annually from 2020-2023. In 2023, the survey covered oyster beds in the Westport area and the time series of biomass for Westport only is presented in Table 22.

Table 22. Stock biomass trends for native oyster in Westport, Clew Bay 2020-2023.

Year	Month	Survey Area (km^2)	Biomass	Biomass km^{-2}
2020	November	0.28	15.04	53.71
2021	November	0.53	18	33.96
2022	December	0.47	23.3	49.57
2023	December	1.33	22.6	16.99

11.8.2 Survey December 2023

A survey of native oysters (*Ostrea edulis*) was carried out on 5th December 2023 in the Westport area of Clew Bay. A total of 62 tows were undertaken over 3 beds in Westport Bay, encompassing a combined surveyed area of 1.33 km^2, with a total sampling effort of 6,554 m^2.

A geostatistical model was not used to analyse this survey data due to high levels of uncertainty in the output. The density (number of oysters per m^2) for each tow was calculated by multiplying the area of each tow by the number of oysters caught. The densities were subsequently interpolated using an Inverse Distance Weighting (IDW) algorithm. Contours were drawn at intervals reflecting the range in observed densities. A dredge efficiency of 35 % was applied to assessment outputs, calculated as the average of different dredge efficiency experiments in oyster beds around Ireland.

11.8.2.1 Distribution and Biomass in 2023

Densities of native oysters (*Ostrea edulis*), uncorrected for dredge efficiency and including all sizes, varied from 0 - 3.78 individuals.m^{-2}. Densities were higher in the northern part of the survey area (Figure 64). Density of oysters over 76 mm ranged from 0 - 0.087 individuals.m^{-2}.

The biomass of native oysters, assuming a dredge efficiency of 35 % was 22.6 tonnes (Table 22). The equivalent biomass of oysters 76 mm or over was 4.9 tonnes or 22 % of the total biomass.

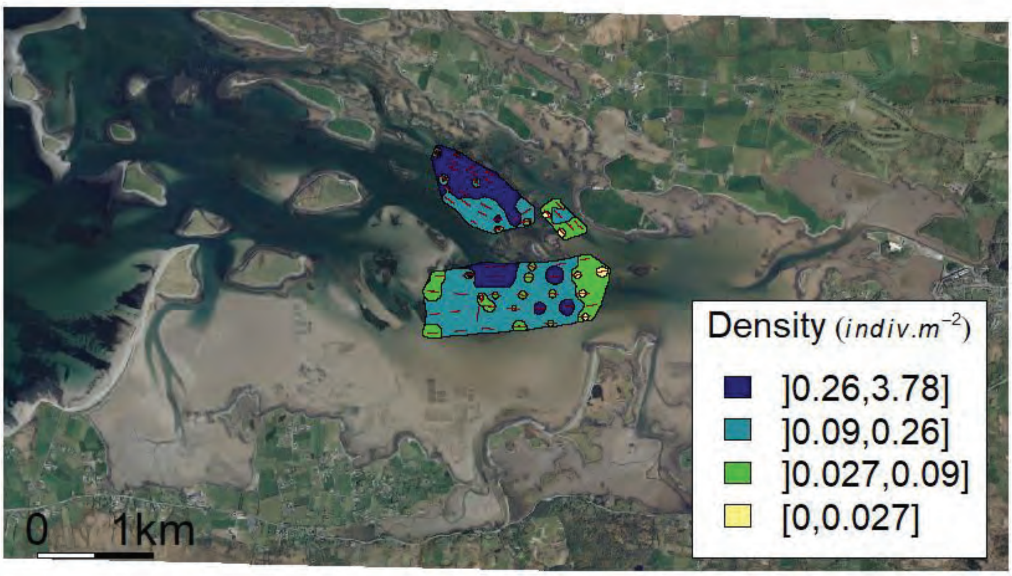


Figure 64. Density of native oysters in Westport area, Clew Bay, December 2023 (uncorrected for dredge efficiency).

11.8.2.2 Size distributions

The size distribution of native oysters in the survey showed two small modes at approximately 27 mm and 34 mm with a low proportion of oysters above the 76 mm minimum landing size (Figure 65). A mode at 55 mm was evident in the 2022 data. Evidence of recruitment is very weak and there is a significant decrease in the density of oysters compared to 2022. Possible causes of this large change in density could be explained by numerous factors; catchability between survey vessels, mortality due to low salinity, siltation and sediment movement, increased mortality caused by fishing or mortality caused by *Bonamia*.

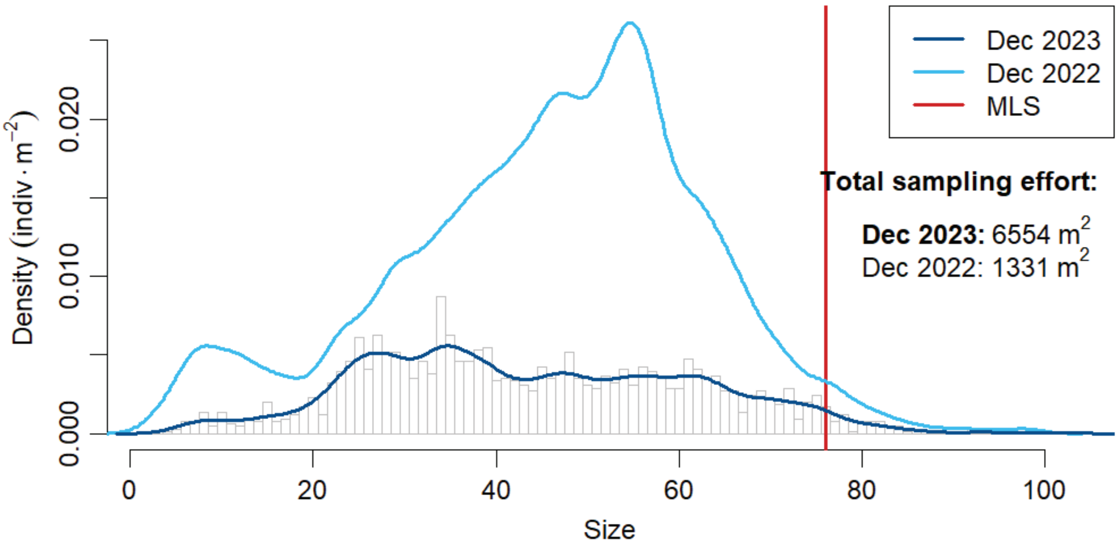


Figure 65. Size distribution of native oysters in Westport, Clew Bay, December 2023 (uncorrected for dredge efficiency). The size distribution for December 2022 is also included for comparison.

11.9 *Native Oyster Restoration – a case study using cultch*

Oyster spat require 'clean' hard substrate on which to settle. Any bivalve shell and many artificial substrates are suitable for oyster settlement. Productive oyster beds produce new shell through recruitment and growth. In cases where fishing is absent or well managed, limited amounts of shell (live oysters) are removed and the shell budget is positive i.e. more shell is produced than is lost through removal or fragmentation caused by dredging or natural disturbance from wave action. This may not be the case where fishing is uncontrolled and where recruitment declines. Wave action and fishing can both bury shell and upturn new shell that may be suitable for settlement. In estuarine conditions in particular where the siltation rate may be high new shell may be covered by silt, rendering it unsuitable for oyster spat settlement.

Spreading of clean bivalve shell (cultch) is one method of providing new clean substrate to increase the shell budget and to enhance spat fall, especially where there is evidence of low shell cover on the seabed which may be causing a bottleneck to recruitment. Surveys undertaken in Galway Bay since 2010 indicate poor shell availability in many areas.

In June 2021, 200 tonnes of whole flat scallop shell were deployed in the south St. Georges fishery order area in Galway Bay. The scallop shells were left to settle until sampling commenced in October 2021 using a grab sampler and dredge. Sampling commenced again in June 2022 by snorkelling on the site. Regular monthly sampling was undertaken from June 2022 to January 2024 (Figure 66). An estimated 13.9 million spat settled on scallop cutch in 2021 with a 45 % survival rate in the first year.

A total of 184 samples have been collected to date. The length distribution from each month showed a gradual increase in size until September 2022, when new spat settlement was detected (Figure 66). The average size of spat from October 2021 to October 2023 demonstrates seasonal growth behaviour, where growth increases during the summer months but slows in the winter months (Figure 67). This study shows that provision of shell substrate is a feasible method of increasing settlement and recruitment of oysters and that it can be used at a scale that would have significant population level benefits.

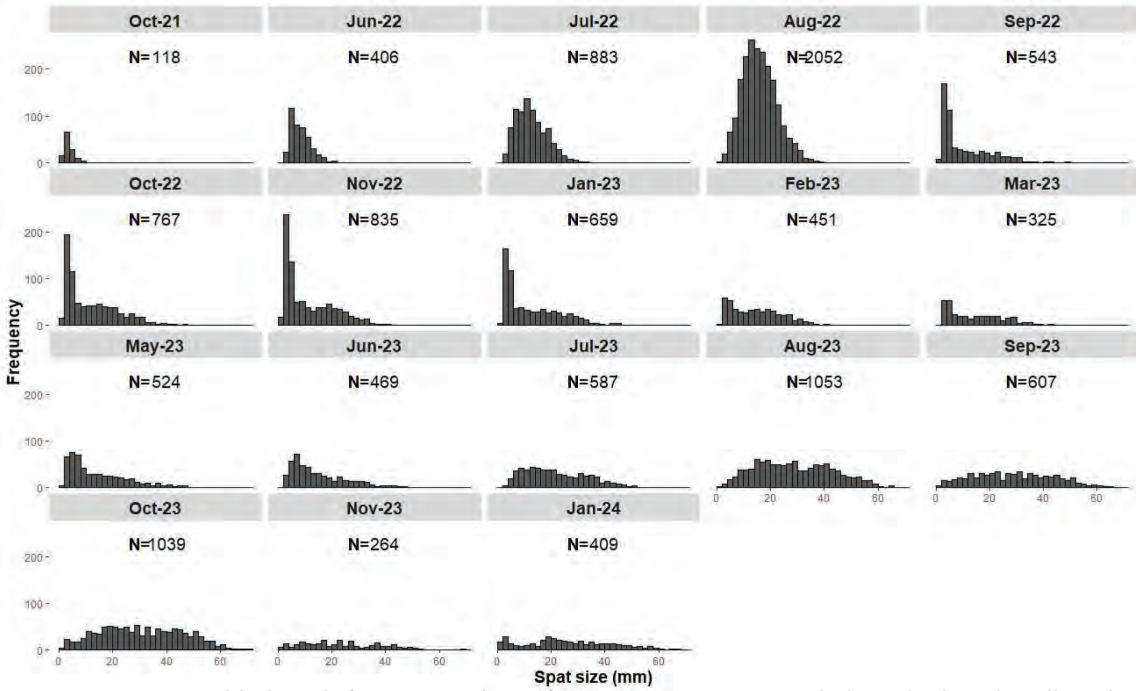


Figure 66. Monthly length frequency plots of native oyster spat settled on deployed scallop shell cultch. N = sample size for each month.

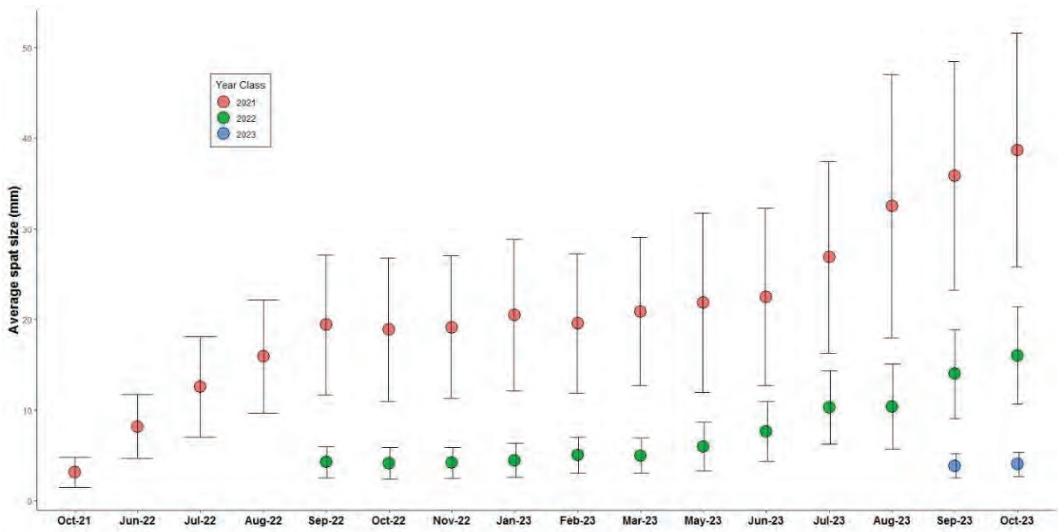


Figure 67. Average size of oyster spat measured on scallop shell cultch between October 2021 and October 2023 for the 2021, 2022 and 2023 year classes.

11.10 *Bonamia spp. Infection in Native Oysters*

Native oyster populations around Ireland are exposed to various pressures including change in environmental conditions, lack of suitable habitat, fishing pressure and diseases and parasites.

Bonamia is a haplosporidian parasite which has contributed to significant mortalities on native oyster beds in Ireland and across Europe. The parasite can be transmitted horizontally (from individual to individual) and vertically (from parent to offspring) and at high intensity can result in a lethal infection of the oyster haemocytes (blood cells).

Bonamia infection was first detected in Ireland in Inner Galway Bay in the 1980's. Over time, more of the beds on the west coast have also become infected, except for Tralee Bay, which has remained *Bonamia* free to date. The distribution of the parasite in the Northeast Atlantic is patchy, so the infection of one area does not ensure the transfer of infection to a neighbouring area.

There is no national monitoring programme currently in place as the parasite is endemic and no mitigations to reduce its impact have been identified. Despite this, monitoring has taken place under different funding schemes over the years and prevalence (the % of oysters positive for *Bonamia*) are reported for all samples. The quantification of the infection (intensity or level of infection) has been reported in some years. *Bonamia* prevalence in Galway Bay has been monitored over a number of years (1993-2023) (Table 23; Figure 68).

Data from 1993-2023 suggest that small sample sizes (<80) may lead to underestimation of *Bonamia* prevalence. Small samples were taken in 1999-2017 (Table 23). Prevalence declined from 1993-1997 and was usually higher in spring samples compared to autumn samples at that time (Figure 68). Prevalence was below 20 % from 1997-2017 although sample sizes were low during this time. Prevalence declined from 38 % in 2018 to 10 % in 2021 and 2 % in 2023. However, the 2018 estimate is not directly comparable as PCR methods were used in that year instead of the heart smear method that had been used in other years.

Table 23. Sample size screened for *Bonamia* infection (N) and prevalence of *Bonamia* (%) detected in various locations in Galway Bay 1993-2023.

Year	Autumn		Spring		All	
	N	%	N	%	N	%
1993	600	37.8	139	53.9	739	41.0
1994	298	25.7	505	36.2	803	32.7
1995	242	27.6	294	10.5	536	17.4
1996	446	13.6	318	39.8	764	24.1
1997	-	-	148	8.8	148	8.8
1999	30	16.6	-	-	30	16.6
2000	41	7.3	-	-	41	7.3
2001	30	10.0	-	-	30	10.0
2002	30	10.0	30	17.0	60	13.5
2004	30	10.0	30	0.0	60	5.0
2006	30	0.0	-	-	30	0.0
2007	30	0.0	-	-	30	0.0
2013	50	6.7	-	-	50	6.7
2017	-	-	30	13.3	30	13.3
2018	302	37.8	-	-	302	37.8
2020	-	-	136	27.7	136	27.7
2021	132	10.5	-	-	132	10.5
2023	200	2	-	-	200	2
All	**2,291**	**19.2**	**1,630**	**24.8**	**3,921**	**21.6**

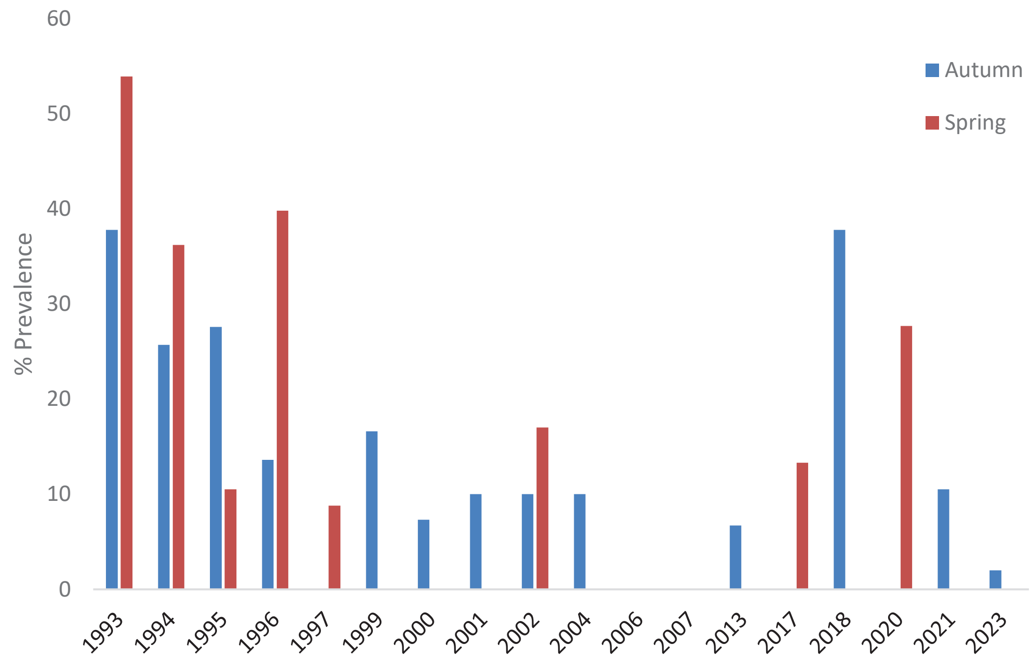


Figure 68. Prevalance of *Bonamia* in samples collected in Autumn and Spring time in Galway Bay between 1993-2023.

Native oysters were screened for *Bonamia* in 2021 and 2023 in Lough Swilly, Clew Bay, Cill Chiaráin, Galway Bay, Rossmore and Tralee bay (Figure 69). Samples were collected in July and November 2021 from Clew Bay (Figure 69 – left graph) to look for seasonal differences in infection. July had a higher prevalence of infection. The prevalence of *Bonamia* in 2023 across all sites was very low (Figure 69 – right graph). Samples were collected between the end of July and beginning of September, when higher prevalence is expected. Continued absence from Tralee Bay was confirmed.

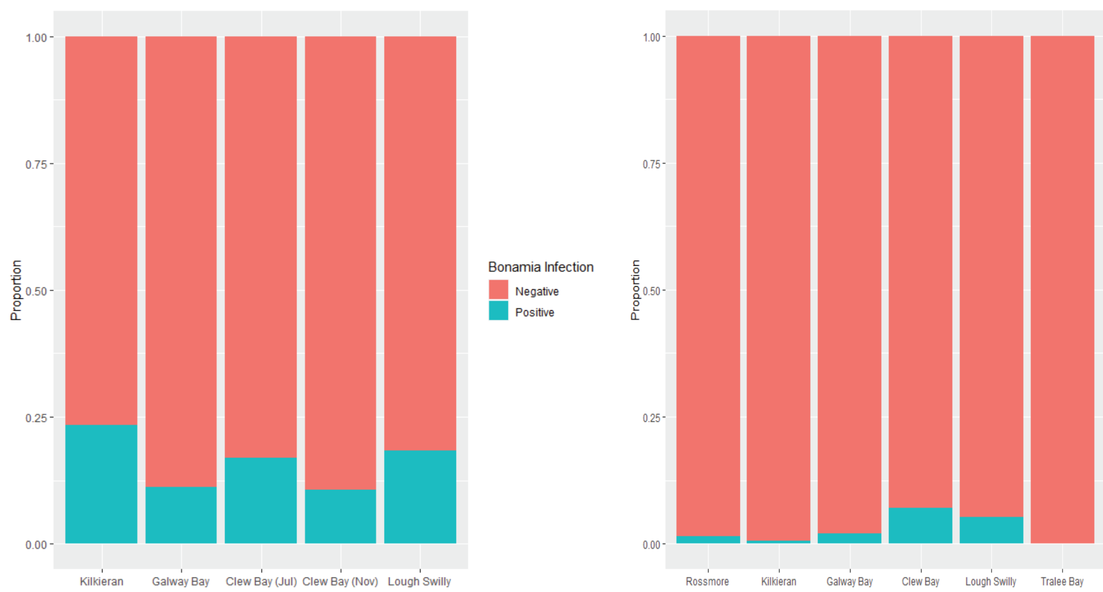


Figure 69. Prevalence of *Bonamia* recorded samples collected in 2021 (left) and 2023 (right). In 2021, samples were collected from Clew Bay in July and November.

Although *Bonamia* infection is known to cause high mortality rates in oysters, demonstrating a link between prevalence, intensity of infection and mortality is difficult. This is a general problem for all diseases and parasites that cause mortalities mainly because the monitoring programme is sampling survivors; *Bonamia* prevalence in dead oysters cannot be compared to prevalence in live oysters. Work that has been carried out on the oyster populations screened for *Bonamia* in 2021 and 2023 shows high mortality rates, especially in larger size classes but linking this to *Bonamia* prevalence given the time lag between infection and mortality is also difficult. Time series monitoring of increases in *Bonamia* intensity and subsequent observations of mortality rates could be done in experimental set ups that follow the progression of both the disease and the progression of mortality.

Past trials and recent evidence suggests that there is differential tolerance or resilience to *Bonamia* in different strains of oysters and that this has a genetic basis. If this is so, then natural selection would be expected to increase resilience over time. The rate at which such resilience could develop depends on the size at which mortality usually occurs relative to the size at first spawning and the heritability of resilience. Oyster mortality from *Bonamia* infections usually increases in the 3rd year of life, at about 50-60 mm. Spawning occurs in oysters as small as 32 mm and mean size at maturity is 49 mm in Galway Bay.

Assessing the scope to select for *Bonamia* resilience and its genetic basis would seem to be important. Screening for the presence and level of resilience in natural populations, using the markers reported in the literature is a first step in this process. This work commenced in 2023 by the Marine Institute. Over 1,100 oysters are being screened for genetic markers for *Bonamia* resilience from Lough Swilly, Clew Bay, Kilkieran Bay, Galway Bay, Tralee Bay and Cork Harbour.

12 Scallop (*Pecten maximus*)

12.1 *Management advice*

The scallop fishery is managed by a minimum landing size of 100-110 mm shell height. There are kilowatt day effort limits in ICES area VII. Seasonal closures apply in the eastern Irish Sea and English Channel. Additional measures may apply locally to inshore stocks.

Offshore scallop stocks in the Irish Sea, Celtic Sea and English Channel are fished by Irish, UK and French fleets. The eastern Channel, Celtic Sea and Cardigan Bay area were the most important areas for the Irish fleet in 2023.

There is currently no integrated international stock assessment or advice for offshore scallop stocks. In Ireland 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 a new survey is reported here for the north Irish Sea in 2023. Offshore surveys are planned from 2024.

Effort distribution across stocks varies annually. From 2006–2012, catch rates increased for most stocks but declined in the period 2013–2016 in the Celtic Sea and Irish Sea. In recent years catch rates have been highest in the eastern Channel. Generally, there is a lot of variability in annual catch rates within and between 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.

Scallop fisheries can have significant negative effects on marine habitats including sedimentary habitats and biogenic reef. Spatial management of scallop fishing should be used to protect habitats within Natura 2000 sites.

12.2 *Issues relevant to the assessment of scallop*

There are currently no assessments or advice for offshore scallop stocks that are fished by Ireland, UK and France. Size and age data are available from opportunistic sampling of landings from Irish vessels and annual surveys were completed in 2003–2005 and 2018-2019 in the Celtic Sea and Tuskar area. Annual surveys are generally undertaken by Northern Ireland, Isle of Man, Scotland, England, Wales and France.

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 show 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 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. Catch rate indicators derived from logbook and VMS data offer scope for future assessment using production models.

12.3 *Management units*

Offshore scallop stocks in the Irish Sea, Celtic Sea and Western and Eastern English Channel are spatially discrete (Figure 70), but some can be variously interconnected during larval dispersal. 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.

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.

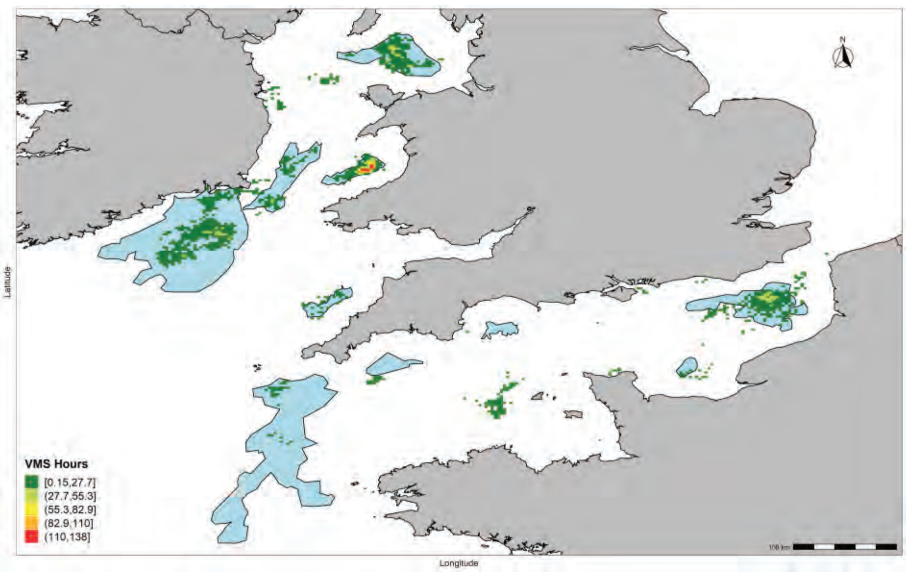


Figure 70. **Scallop grounds fished by the Irish fleet in the Irish Sea, Celtic Sea and English Channel. Boundaries are defined from the distribution of fishing activity by the Irish fleet 2000–2015 as shown by VMS data and some UK VMS data. The stock boundary limits are likely to be larger particularly 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.**

12.4 *Management measures*

In Ireland 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. 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 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 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 at the Saltee Islands and Hook Head, Co. Wexford.

12.5 *Offshore scallop fisheries*

12.5.1 Landings

Landings increased from 1995–2004 due to expansion of the geographic areas fished, particularly in the Celtic Sea (Figure 71). The Irish fleet also 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 71).

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 71). The increase in landings from the Eastern English Channel since 2016 is correlated with a decline in landings from the Celtic Sea (Figure 71).

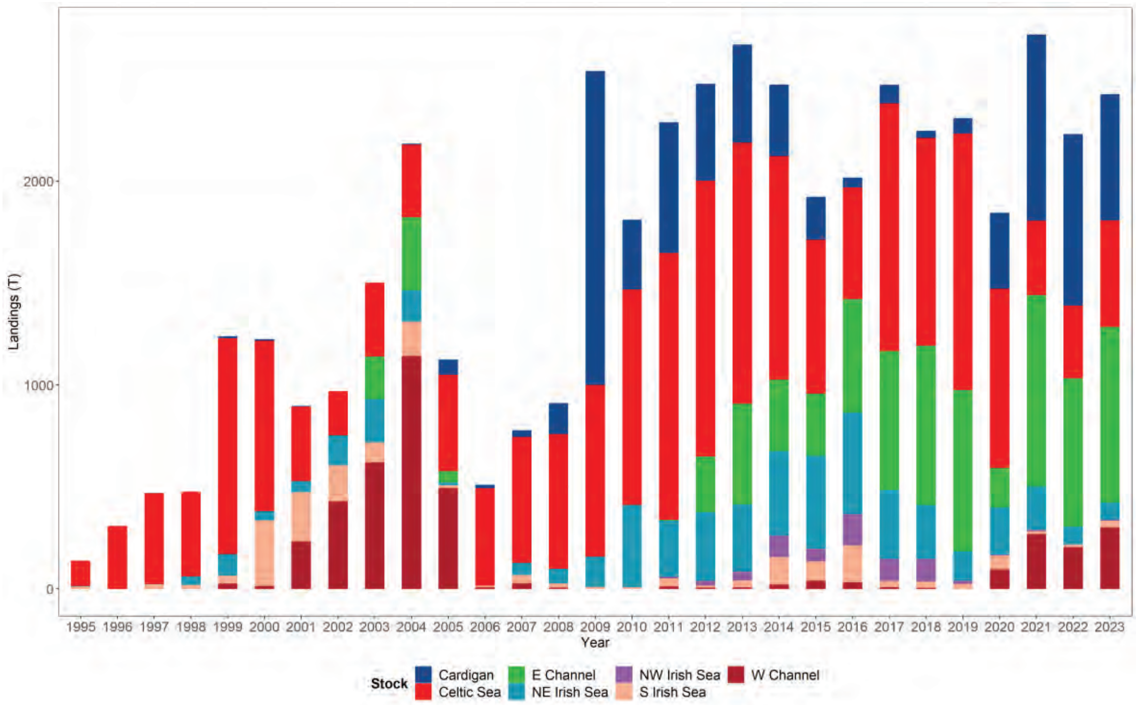


Figure 71. Annual landings of scallop by the Irish fleet from stocks in the Celtic Sea, Irish Sea and English Channel areas 1995–2023.

12.5.2 Catch rate indicators

Catch rates are highly variable between years in each stock area. 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 72). Catch rates declined between 2010 and 2016 in most areas. Catch rates declined substantially in the Western English Channel between 2014 and 2018, although landings and effort in this area were 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 72) which is more than double that of any other area prior to 2019. This area is an extension of the highly productive stocks in French waters. The Cardigan Bay area and western Channel have also yielded high catch rates in recent years. The Irish fleet fish in the eastern Channel 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. In addition, catch rates in the NW Irish Sea decreased in recent years.

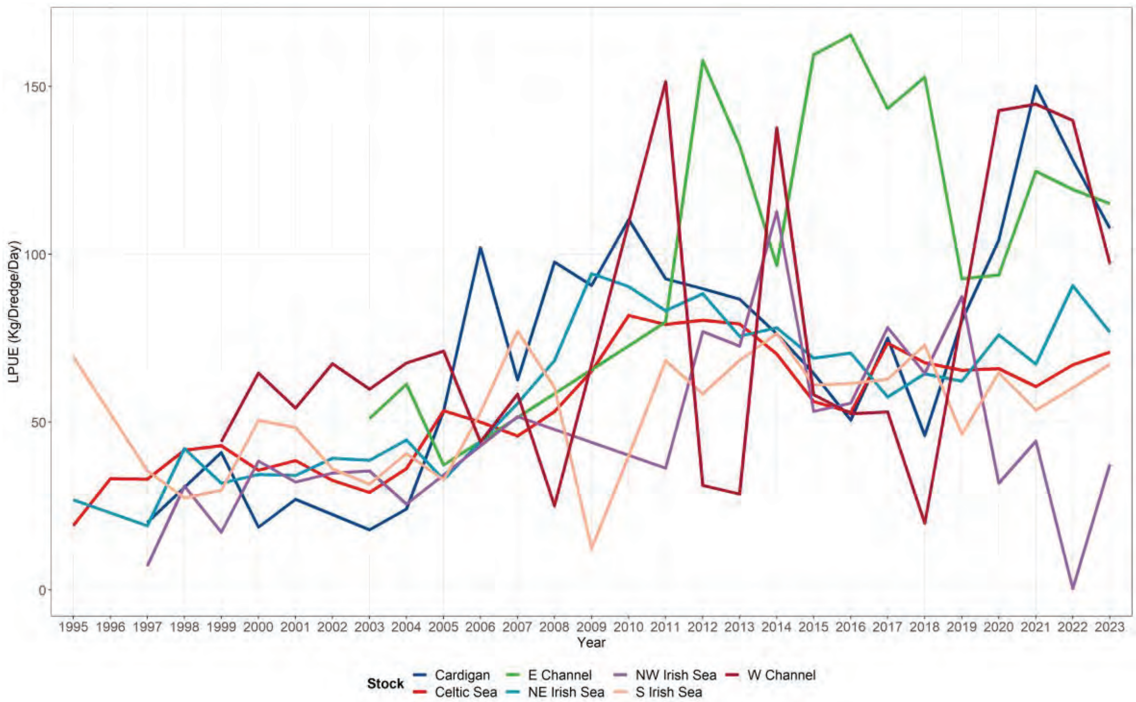


Figure 72. Annual average catch rate (kgs.dredge^{-1}.day^{-1}) from the main scallop stocks fished by the Irish fleet 1995–2023.

12.6 *Scallop surveys and Biomass Assessment*

12.6.1 North Irish Sea survey 2023

Surveys were carried out in April and May 2023 across three king scallop (*Pecten maximus*) beds in the North Irish Sea; Bray Inshore, Bray Offshore and east of Dundalk Bay (Figure 73). A total of 74 tows were carried out across the three beds using 7 x 0.75 m wide spring-loaded scallop dredges.

During the Bray survey, a queenie dredge of 0.75 m width was used to increase catchability of smaller scallops. However, due to uncertainty in the efficiency of this queenie dredge 2 x 0.75 scallop dredges with more teeth and a smaller mesh liner were used during the survey undertaken offshore, east of Dundalk Bay.

Only a limited number of tows were carried out on the Bray beds, particularly on the offshore ground, due to static fishing gear overlapping the area. The beds covered in the survey are subject to intermittent fishing pressure, therefore, scallop had been fished prior to the survey taking place.

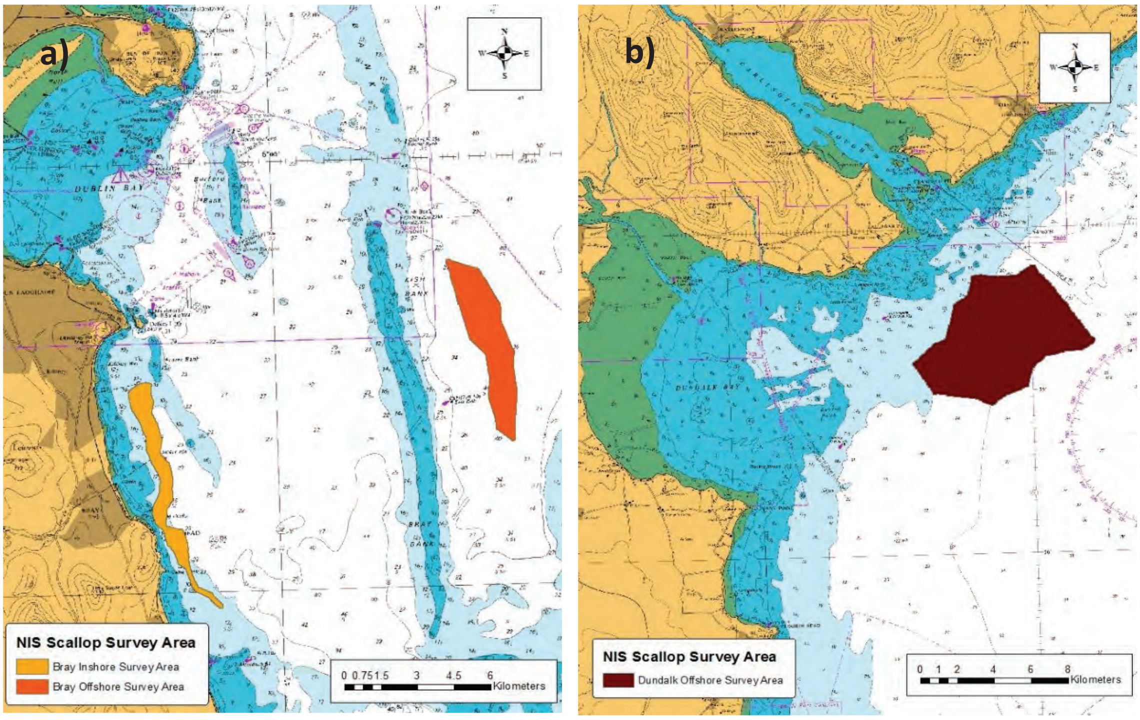


Figure 73. Areas surveyed for Scallops in the North Irish Sea in April/May 2023. a) shows the Bray Inshore and Offshore survey areas, b) shows the Dundalk Bay Offshore survey area.

12.6.1.1 Biomass in 2023

Biomass of scallop on the Bray Inshore bed, uncorrected for dredge efficiency, varied from 0- 0.013 kgs.m^{-2} (Figure 74). Hotspots of biomass were found across the full extent of the surveyed area. Biomass of scallop over 98 mm shell height (equivalent to 110 mm in shell length) ranged from 0-0.02 kgs.m^{-2}.

The total biomass of scallop, uncorrected for dredge efficiency and selectivity, was estimated to be 22 tonnes (Table 24) over a survey area of 5.78 Km^2. The biomass of scallop above the minimum landing size (MLS) of 110 mm shell length or 56% of the total biomass (Table 24).

Table 24. Estimates of scallop biomass (uncorrected for dredge efficiency) in the Bray Inshore survey area, April 2023.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_ *Pecten maximus*	22.0	25.8	16.5	36.0
Biomass_>110mm_ *Pecten maximus*	12.3	13.5	6.7	22.2

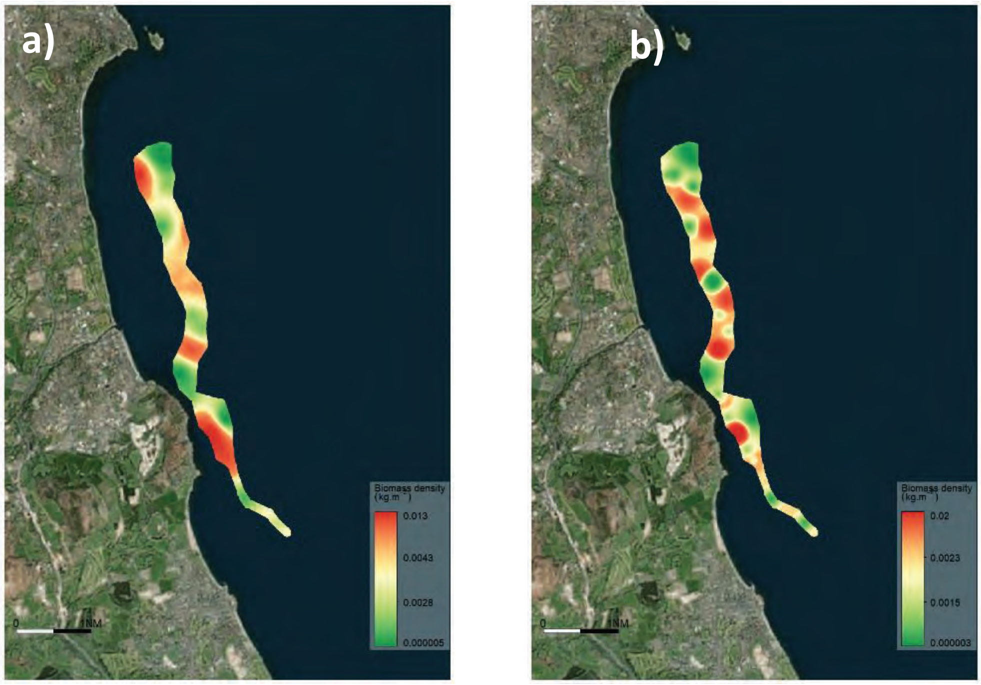


Figure 74. Distribution and biomass of scallop (uncorrected for dredge efficiency) for a) all size classes and b) above MLS or 110 mm shell length on the Bray Inshore bed, October 2023.

Biomass of scallop in the offshore Bray survey area, uncorrected for dredge efficiency, varied from 0- 0.028 kgs.m^{-2} (Figure 75) with higher densities towards the northern half of the surveyed area. Biomass of scallop over 98 mm shell height ranged from 0-0.026 kgs.m^{-2}.

The number of tows carried out on the Bray offshore survey area was limited due to static gear covering the ground and therefore, it is unlikely that the full extent of the scallop bed was surveyed.

The total biomass of scallop, without taking into account the effects of dredge efficiency and selectivity, is estimated to be 8.1 tonnes (Table 25) all of which was above the MLS of 110 mm (equivalent to 98 mm shell height) over a total surveyed area of 9.4 Km^2.

Table 25. Estimates of scallop biomass (uncorrected for dredge efficiency) in the Bray Offshore survey area, April 2023.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_ *Pecten maximus*	8.1	8.1	5.2	12.9
Biomass_>110mm_ *Pecten maximus*	7.8	7.8	4.6	14.0

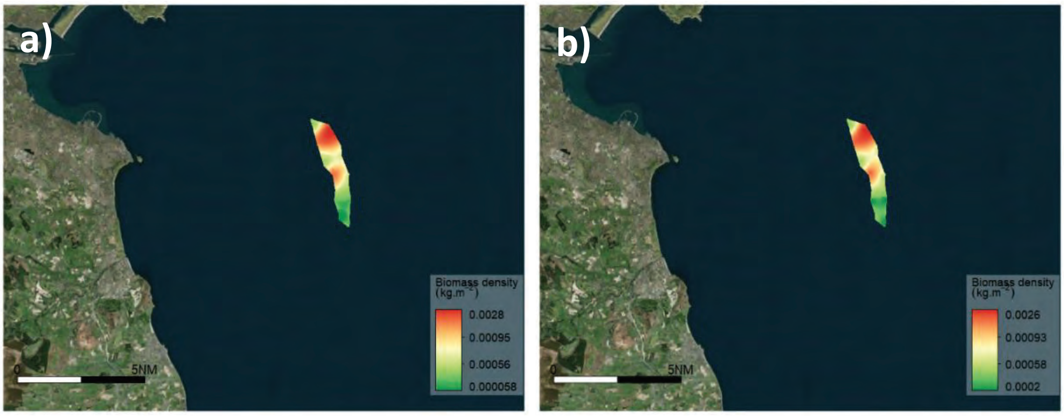


Figure 75. Distribution and biomass of scallop (uncorrected for dredge efficiency) for a) all size classes and b) above MLS or 110 mm shell length in the 2023 Bray Offshore area.

Biomass of scallop in the Dundalk bed, uncorrected for dredge efficiency, varied from 0- 0.0021 kgs.m^{-2} (Figure 76), with higher densities towards the eastern limit of the surveyed area. Biomass of scallop over 98 mm shell height ranged from 0-0.014 kgs.m^{-2}. The higher densities of scallops in the eastern limit of the area, seem to extend further than the current survey limits, and should be taken into consideration in future surveys.

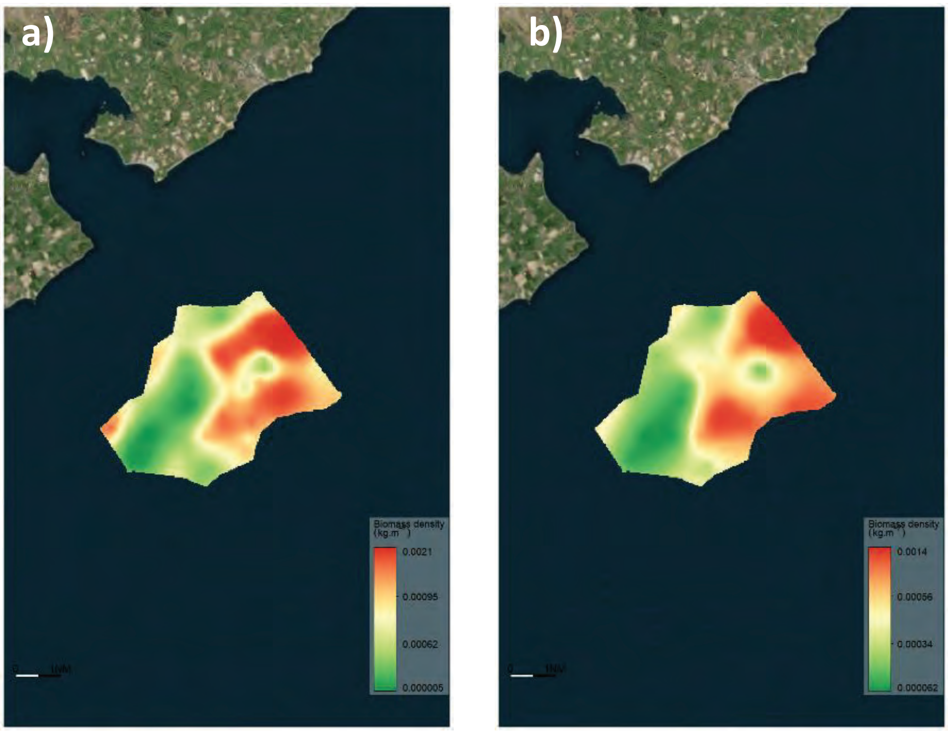


Figure 76. Distribution and biomass of scallop (uncorrected for dredge efficiency) for a) all size classes and b) above MLS or 110 mm shell length in the 2023 Dundalk Bay Offshore area.

The total biomass of scallop, uncorrected for dredge efficiency and selectivity, was estimated to be 34.9 tonnes (Table 26) over a survey area of 44.24 Km^2. The biomass of scallop above the minimum landing size (MLS) of 110 mm shell length was 21.2 tonnes or 60.7% of total biomass (Table 26)

Table 26. Estimates of scallop biomass (uncorrected for dredge efficiency) in the outer Dundalk Bay survey area, May 2023.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_ *Pecten maximus*	34.9	36.3	30.3	42.9
Biomass_>110mm_ *Pecten maximus*	21.2	23.3	18.2	28.9

12.6.1.2 Size distribution

The size distribution of scallop recorded in the Bray Inshore area from the survey shows a main size cohort at about 110 mm shell height (Figure 77), and a second cohort of smaller scallops ~80 mm but in lower numbers, suggesting that recruitment is occurring in the area.

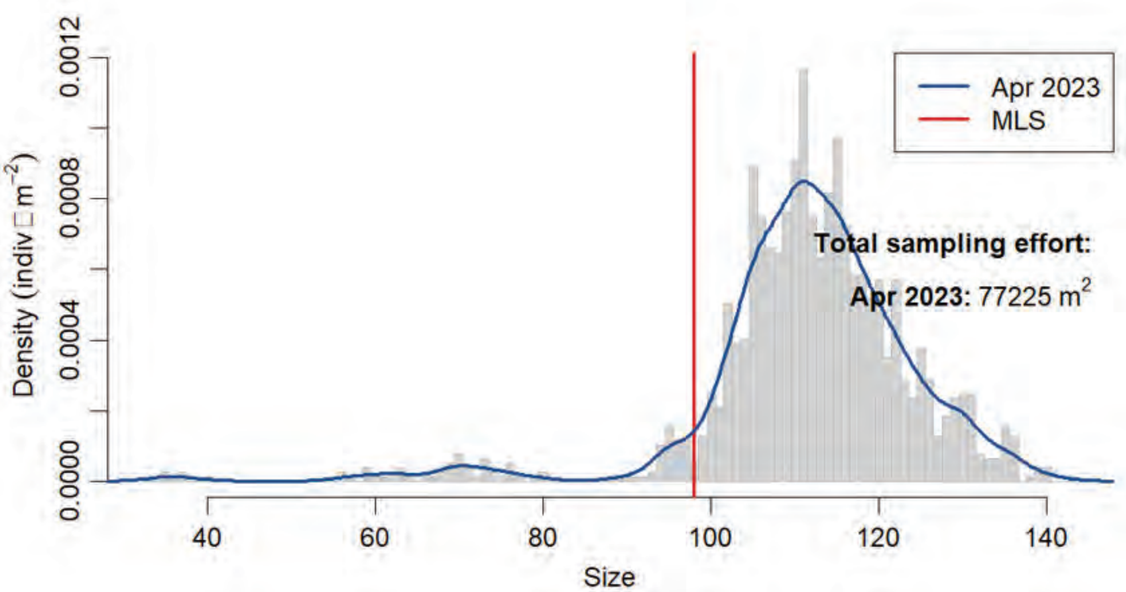


Figure 77. Size distribution and densities of scallop in the Bray Inshore bed, April 2023. The size data presented here are measurements of scallop shell height (mm). Vertical red line corresponds to the MLS of 110 mm shell width (98 mm shell height).

The size distribution of scallop recorded in the Bray Offshore bed shows a main modal size at approximately 125 mm, but very low numbers were recorded due to the limited number of tows (Figure 78). No small scallops (<100 mm) were found in this bed.

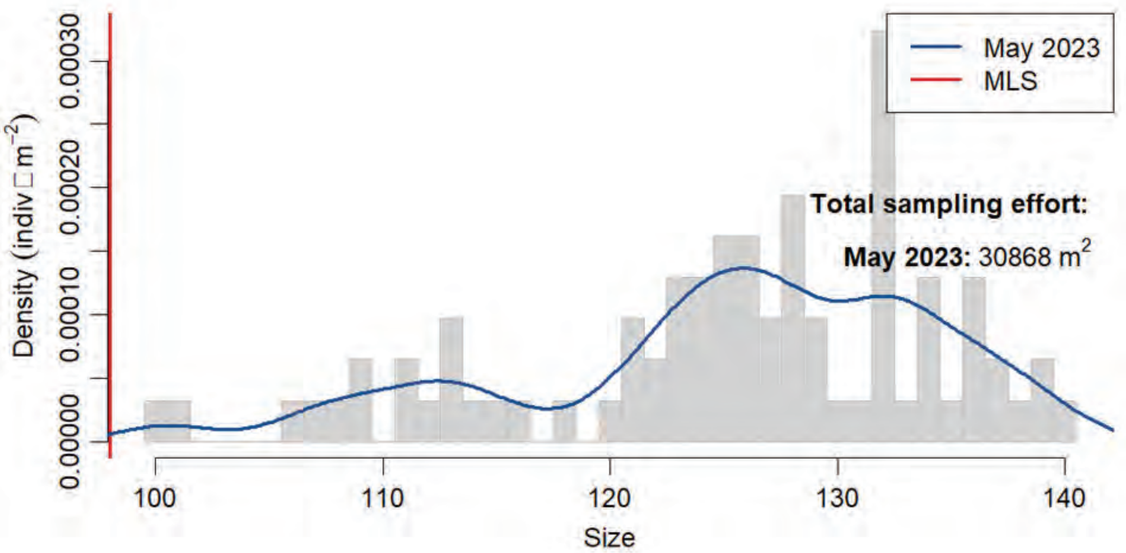


Figure 78. Size distribution and densities of scallop in the Bray Offshore bed, May 2023. The size data presented here are measurements of scallop shell height (mm). Vertical red line corresponds to the MLS of 110 mm shell width (98 mm shell height).

In the offshore area of Dundalk Bay a prominent size cohort at approximately 120 mm shell height was evident (Figure 79), but significant numbers of scallops below the MLS limit were also present suggesting recruitment occurs within the area.

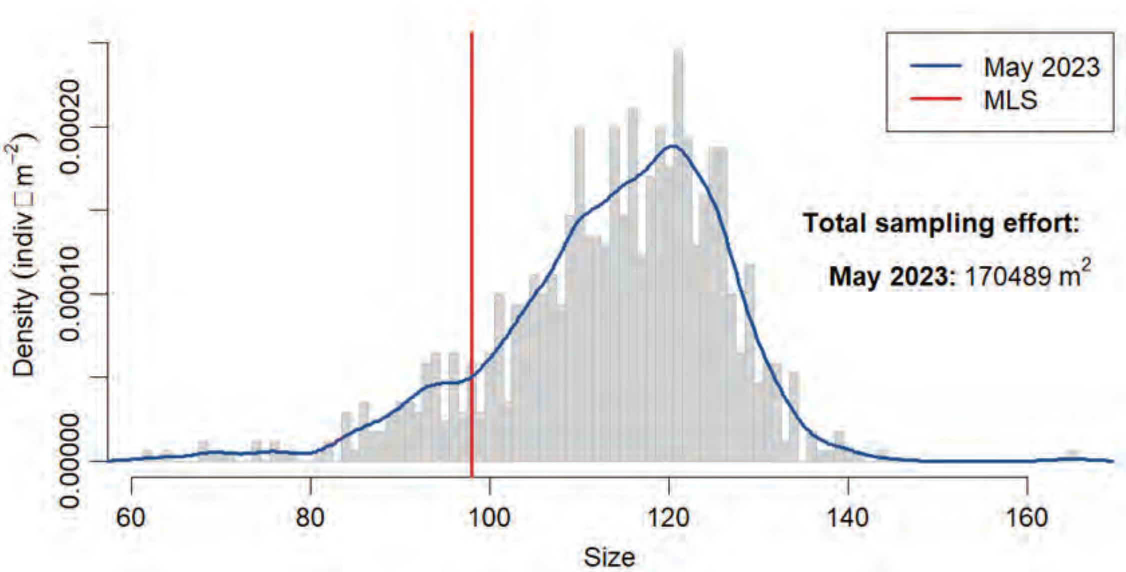


Figure 79. Size distribution and densities of scallop in the Dundalk Bay offshore bed, May 2023. The size data presented here are measurements of scallop shell height (mm). Vertical red line corresponds to the MLS of 110 mm shell width (98 mm shell height).

12.6.2 Comharchumann Sliogéisc Chonamara (Galway) Survey 2023

A survey was carried out on the 16th and 17th October on the scallop (*Pecten maximus*) beds of Cill Chiaráin and Caisín Bays. A total of 53 tows were completed in Cill Chiaráin and Caisín Bays using 3 x 0.75 m wide spring-loaded scallop dredges. Scallop catch and bycatch were recorded, weighed and measured on board from each tow. The local shellfish co-operatives, Comharchumann Sliogéisc Chonamara (CSC), minimum landing size for scallop is 120 mm shell width which is equivalent to 104 mm shell height. 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.

12.6.2.1 Biomass in 2023

Biomass of all scallops and scallops over 120 mm shell width (104 mm equivalent in shell height) in Cill Chiaráin Bay, uncorrected for catchability, varied from 0.00084-0.047 kgs.m^{-2} and 0.0054-0.029 kgs.m^{-2}, respectively (Figure 80).

The total biomass of scallops and scallops over 120 mm shell width in the survey area of 2.66 Km^{2}, uncorrected for catchability, was estimated to be 52.02 tonnes and 45.26 tonnes, respectively (Table 27). This was an increase on the biomass estimates from the 2022 survey of 7 tonnes. Growth of the larger cohort between 2022 to 2023 could explain this increase in biomass. However, uncertainties about the efficiency of the gear can result in inter-annual variability in the biomass estimates.

Table 27.Estimates of scallop biomass (uncorrected for dredge efficiency) in Cill Chiaráin Bay survey area, October 2023.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_*Pecten maximus*	52.02	55.20	45.96	66.92
Biomass_>120mm_ *Pecten maximus*	45.26	47.50	38.52	55.98

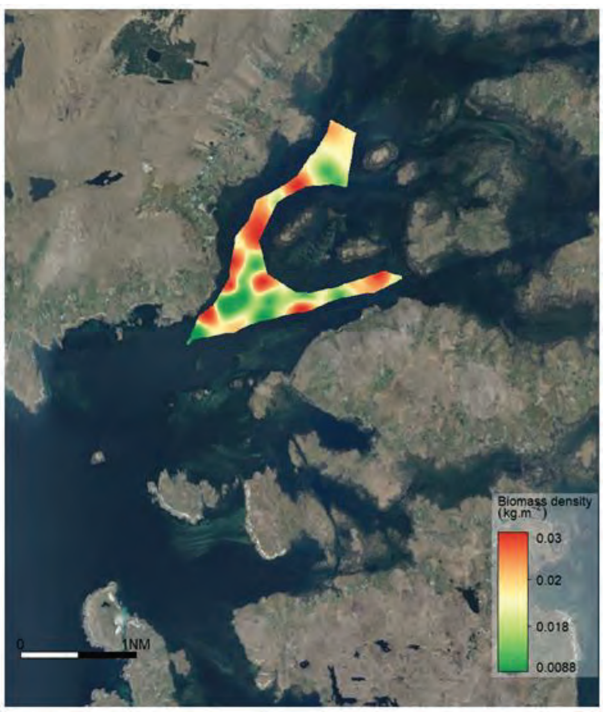


Figure 80. Distribution and biomass of all sizes of scallop (uncorrected for dredge efficiency) in Cill Chiaráin Bay, October 2023.

Density of all scallops and scallops over 120 mm shell width in Caisín Bay, uncorrected for catchability, varied from 0.00068- 0.024 kgs.m^{-2} and 0.00086-0.016 kgs.m^{-2}, respectively (Figure 81).

The total biomass of scallops and scallops over 120 mm shell width in the survey area of 1.4 Km^2, uncorrected for catchability, was 11.16 tonnes and 8.54 tonnes (76% of total biomass), respectively (Table 28). This was an increase on the 9.6 tonnes estimated from the 2022 survey. This is most likely explained by the slightly larger survey area in 2023 and growth in the largest cohort since the 2022 survey.

Table 28. Estimates of scallop biomass (uncorrected for dredge efficiency) in Caisín Bay survey area, October 2023.

	Biomass (tonnes)		95% HDI inf	95% HDI sup
	Mean	Median		
Uncorrected for Dredge Efficiency				
Biomass_ *Pecten maximus*	11.16	11.14	8.82	13.68
Biomass_>120mm_ *Pecten maximus*	8.54	8.61	6.64	11.04

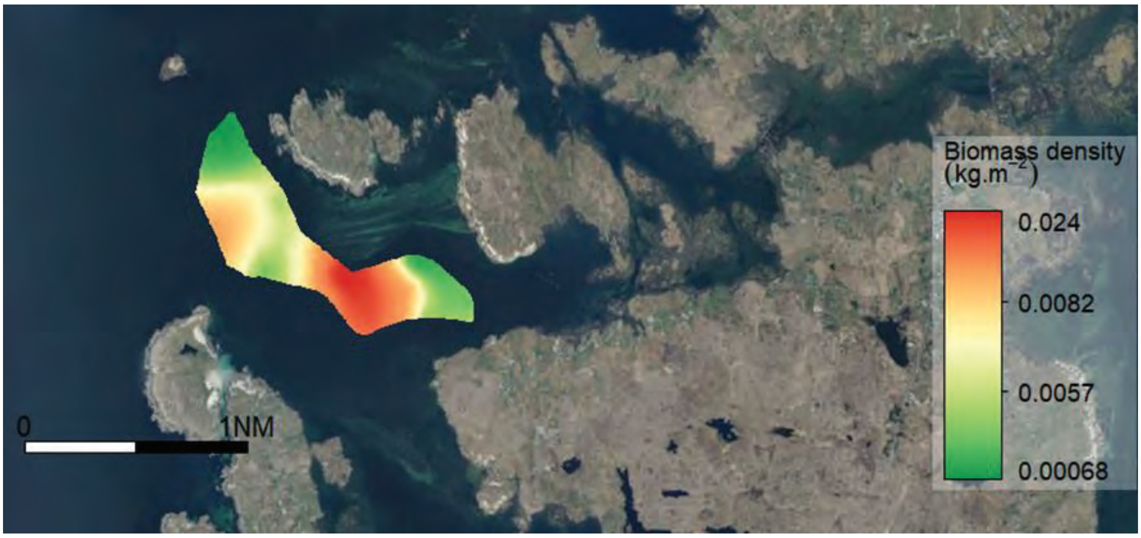


Figure 81. Distribution and biomass of all sizes of scallop (uncorrected for dredge efficiency) in Caisín Bay, October 2023.

12.6.2.2 Size distribution

The size distribution of scallop in Cill Chiaráin Bay showed a strong mode at ~115 mm shell height and a larger cohort at 125 mm (Figure 82). Two smaller size cohorts were also recorded at 94 mm and 105 mm shell height. The 2023 size distribution data indicates growth of the larger size cohort since the 2022 survey. The size distribution of scallop in Caisín Bay showed a mode at ~106 mm (Figure 83). A larger size cohort at ~116 mm shell height indicates growth in the population since the 2022 survey.

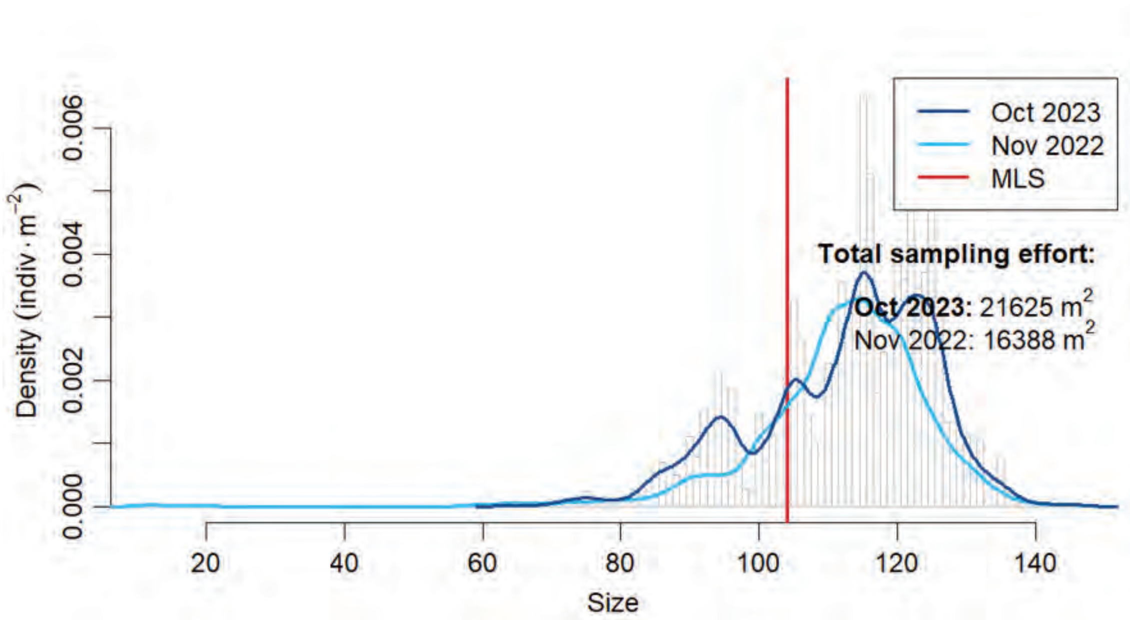


Figure 82. Size distribution and densities of scallop in Cill Chiaráin Bay October 2023. The size data presented here are measurements of scallop shell height (mm). Vertical red line corresponds to the CSC MLS of 120 mm shell width (104 mm shell height). The size distribution of scallop from the November 2022 survey is included for comparison.

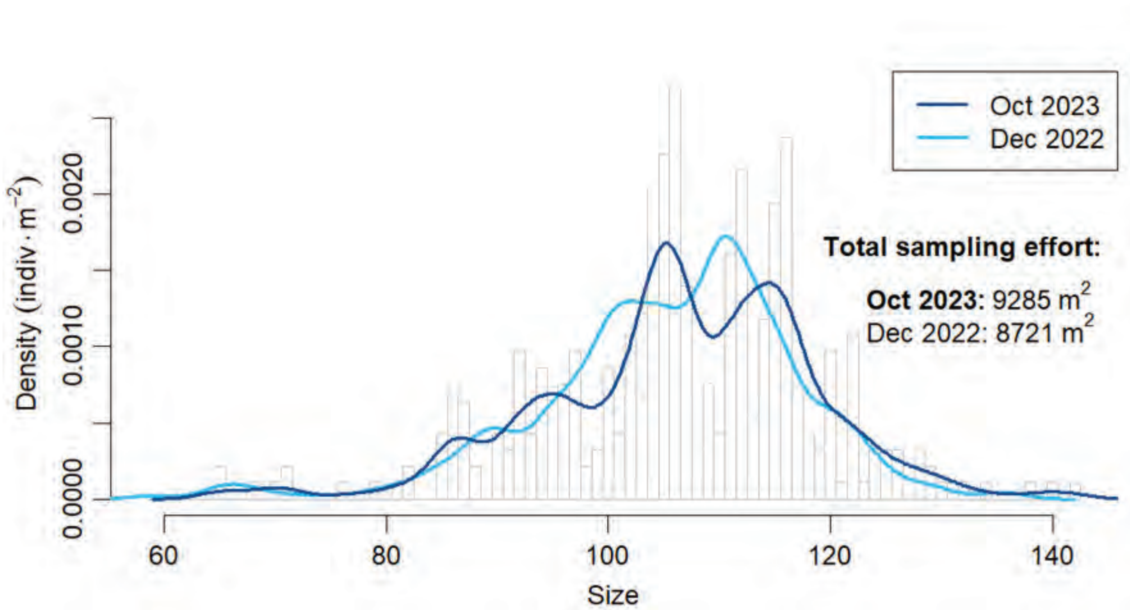


Figure 83. Size distribution and densities of scallop in Caisín Bay October 2023. The size data presented here are measurements of scallop shell height (mm). Vertical red line corresponds to the CSC MLS of 120 mm shell width (104 mm shell height). The size distribution of scallop from the December 2022 survey is included for comparison.

13 Whelk (*Buccinum undatum*)

13.1 *Management Advice*

Whelk stocks are managed through a minimum landing size (MLS) regulation of 25 mm shell width. The main whelk fishery occurs in the south Irish sea, from Howth to Rosslare, with a smaller fishery north of Malin Head, Co. Donegal.

Growth overfishing reference points and current fishing mortality rates were estimated in the areas fished by vessels landing into Wicklow, Arklow and Courtown harbours. Outputs indicate growth overfishing in the Arklow and Courtown harbours fishing areas but not in the area fished by vessels out of Wicklow, although an increasing trend in mortality is also observed in recent years for this area.

Catch rate indicators from SVP data, for the period 2014-2022, were stable but clearly lower than in the period 2006-2008.

The size at maturity is likely to be significantly higher than the MLS and the reproductive potential of the stock may not be sufficiently protected. Whelk have no larval dispersal phase and are vulnerable to local depletion.

Fishing mortality should be reduced to optimise yield and avoid growth overfishing. As the catch rate indicators have declined and as it is likely that size at maturity is well above the minimum landing size there is a risk of recruitment overfishing.

13.2 *Issues relevant to the assessment of the whelk fishery*

Common whelk have been fished commercially in the south Irish Sea, from Howth to Rosslare, since the 1960s.The fishery expanded in the early 1990s due to new markets in South Korea and Japan. The fishery is managed by a minimum landing size of 25 mm shell width. Biological characteristics such as growth rate and size at maturity are known to vary geographically.

Area based assessment and management within the Irish Sea may be necessary given the probably complex population structure and spatial variability in growth and reproduction. Sampling requirements for length or age based assessments are onerous given the spatial and seasonal variability in size composition and growth rates. The size at maturity is likely to be well above the minimum landing size (MLS) and it may, therefore, not be feasible to manage solely using MLS as increasing the MLS to the average size at maturity would severely limit landings.

Data provision is currently limited to sampling at processing plants where large samples from across a high proportion of vessels are obtained. These samples can be traced to port of landing and the likely sea area where the vessel was fishing. Some catch and effort data is reported by a small number of vessels through the Sentinel Vessel Programme (SVP).

13.3 *Management units*

Although whelks are common in many areas around the Irish coast commercial sized populations occur mainly in the Irish Sea south of Howth and to a much lesser extent in a small area north of Malin Head, Co. Donegal. Some fishing occurs north of Howth in the Irish Sea and also episodically and at small scale in other areas around the coast.

Whelks do not have a dispersive larval phase so dispersal capacity is limited. Individual stocks almost certainly exist in different coastal areas. Stock area definition in the South Irish Sea has been discussed in the past (Caddy 1989, Fahy et al., 1995). In the south Irish Sea size composition, growth rates and size at maturity all vary spatially suggesting some degree of isolation of stocks in different areas although all of these biological characteristics could also be environmentally determined. The physical environment in the south Irish Sea is also dynamic and dispersive which may also play a role in the dispersal of whelk in the region. Nevertheless, if the objective is to manage local fishing mortality and to adjust the minimum size to optimise yields and egg production then separate management units may need to be identified in the south Irish Sea.

13.1 *Landings and Catch Rates*

Whelk landings in counties Dublin, Wicklow and Wexford by Irish vessels were collated from 2014-2022 (Figure 84). Landings prior to 2014 are in the process of extraction to re-construct the time series. County Wicklow has accounted for the majority of the landings with approximately 2,000 tonnes of whelk landed every year but almost 2,500 tonnes in 2020 and 2021. Landings in Counties Wexford and Dublin have mostly remained below 1,500 tonnes per annum. A decrease in landings has occurred in the county Dublin fishing area in recent years, whereas landings in county Wexford are stable. Dun Laoghaire, Howth, Rosslare, Wexford town and Courtown, are the main landing harbours in these counties.

Data from the Sentinel Vessel Fleet programme (SVP) from 2014-2022 in the South Irish Sea targeting whelk was collated for this report (Table 29). SVP landings reported as boxes were transformed to Kg applying a ratio of 40 (average weight of a box of landed whelk). LPUE's above 7.5 Kg/Pot were considered unrealistic and removed. SVP data was merged with previously reported LPUE's in the area from 2006-2008, recorded in BIM voluntary logbook data (Figure 85). Both datasets were projected into ICES Statistical rectangles (1 longitude x 0.5 latitude degrees) to provide information on the spatial distribution of fishing. Nevertheless, fleet sampling coverage in both periods is limited, representing approximately 5-20 % of vessels in the fishery depending on year. Spatial data for the period 2006-2008 was only available to latitude 53.5° North. LPUE estimates across and within periods might be biased (unrepresentative of the fleet in general or locally) and spatial coverage of the fishing grounds is limited.

LPUE's reported in the period 2006-2008 were slightly higher than in the recent time series. LPUE was stable during the period 2014-2022 ranging from 1.5-2 Kg/Pot. Only three statistical rectangles are consistently reported across the time series (33E3, 34E3, 35E4) (Figure 86 and Figure 87). A step change reduction in LPUE's between these time periods is evident across the three rectangles.

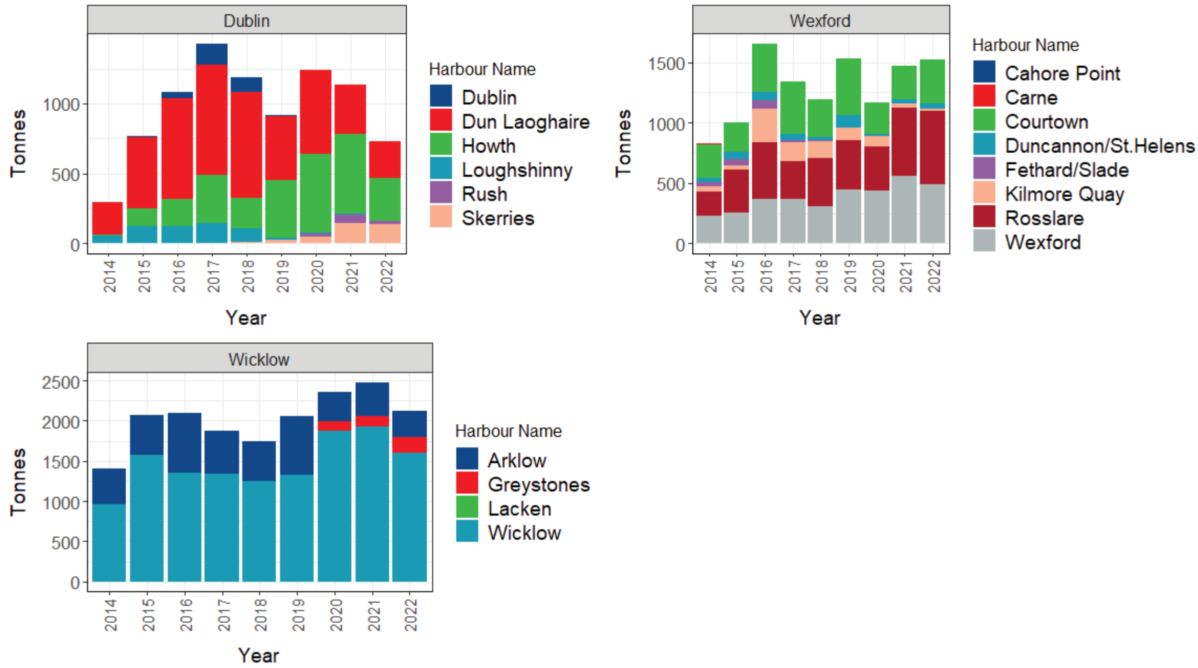


Figure 84. Whelk landings by County and Harbour 2014-2022. Source: SalesNotes (<10m vessels) and Logbooks (>10m vessels).

Table 29. SVP summary for boats participating in the South Irish Sea whelk fishery.

Year	Vessels	Fishing Days	ICES Rectangles
2014	7	395	3
2015	12	604	5
2016	7	504	3
2017	6	432	2
2018	6	498	3
2019	6	530	4
2020	5	321	3
2021	3	391	2
2022	3	303	2

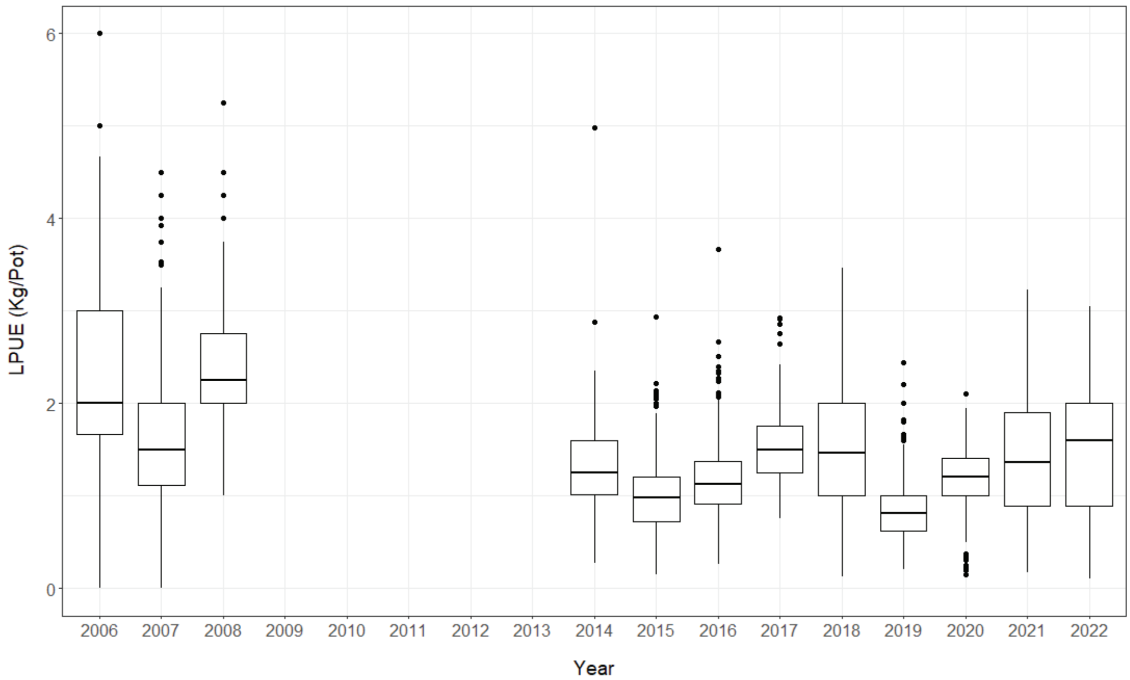


Figure 85. Whelk LPUE as Kg/Pot in the South Irish Sea from 2006-2008 data (voluntary logbook data BIM) and the SVP programme (2014-2022).

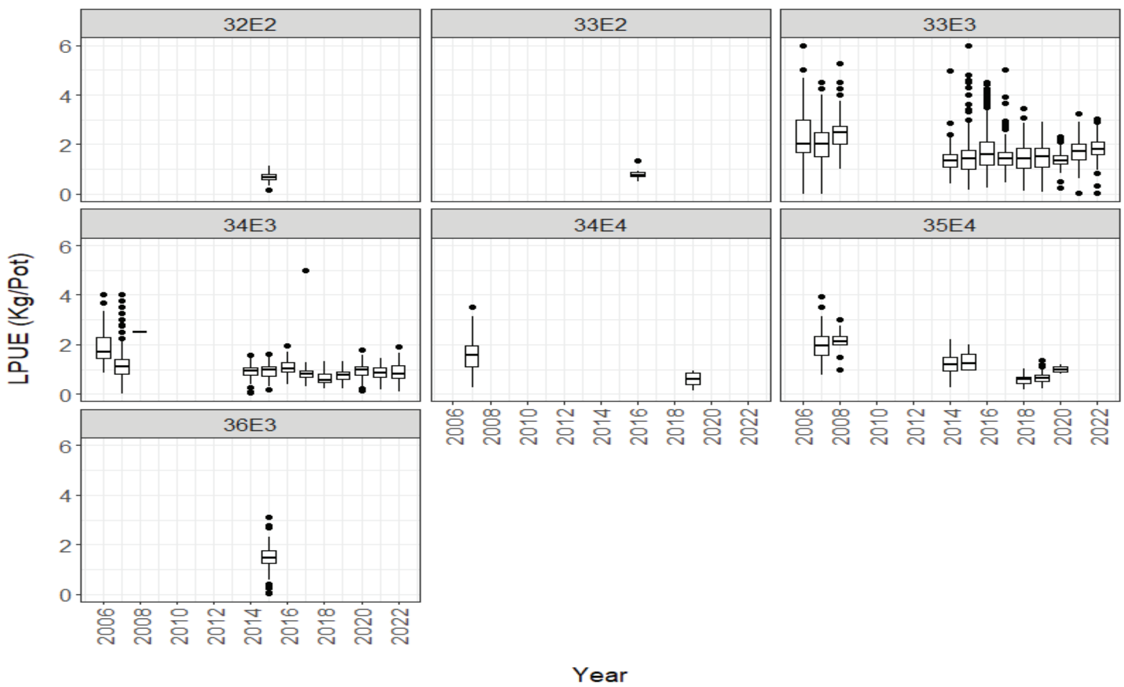


Figure 86. Whelk LPUE (Kg/Pot) in the South Irish Sea by ICES Statistical Rectangle from 2006-2008 data (voluntary logbook data BIM) and the SVP programme (2014-2022).

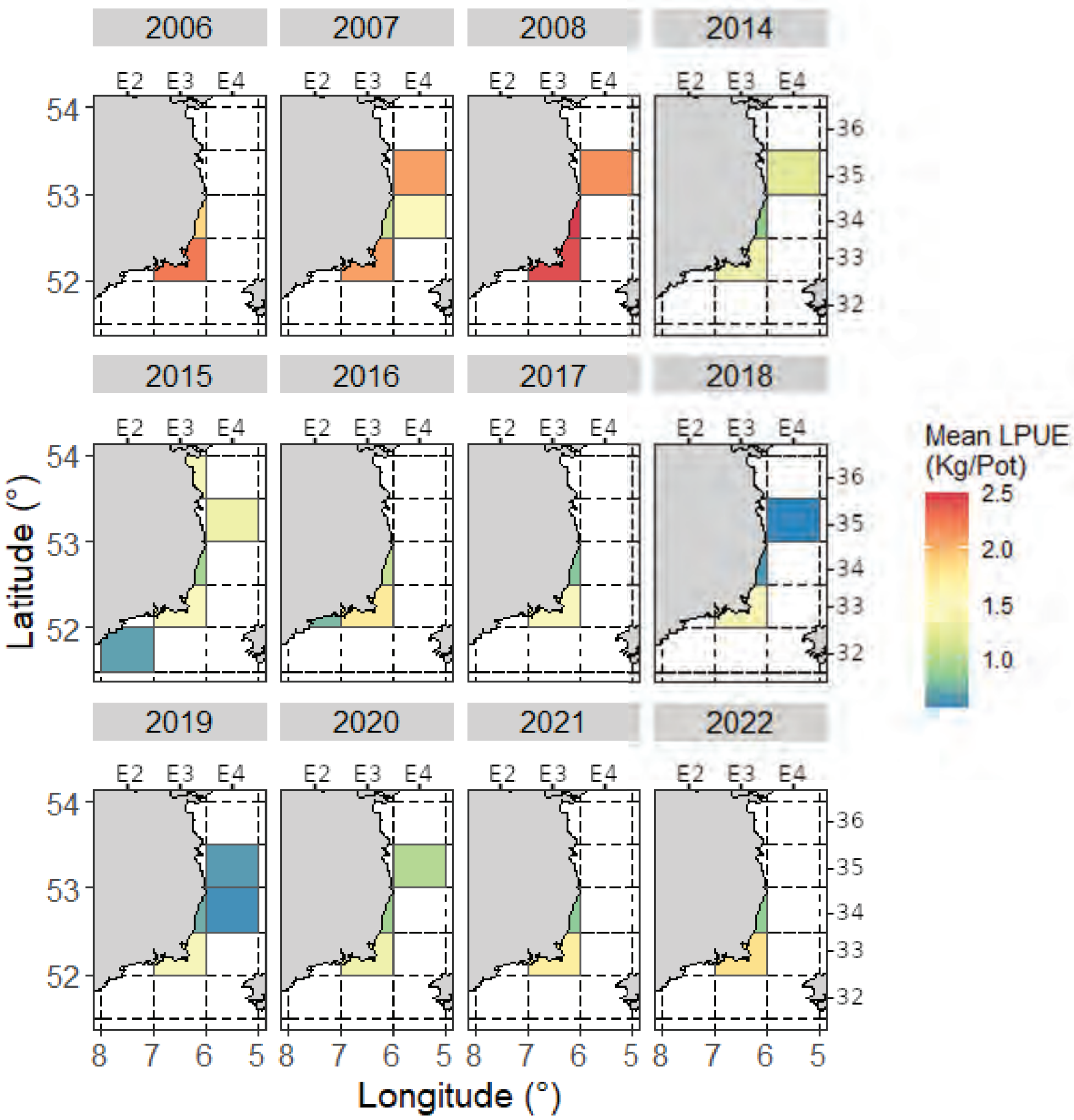


Figure 87. Annual average LPUE (KG/Pot) by ICES Statistical Rectangle from 2006-2008 data (voluntary logbook data BIM) and SVP programme (2014-2022).

13.2 *Whelk Landings Port Sampling Data*

A monthly (where possible) sampling programme to gather size data of whelk (*Buccinum undatum*) in the landings has been undertaken since 2007. Data collated in this report extends from 2014 to 2022 (Figure 88). Work is ongoing to include data collected prior to 2014 and from 2023.

Size sampling from 2014-2022 was extensive. Although not design based, samples were taken across a high proportion of vessels in each month (Table 29)**.** Size samples collected on a given date were firstly raised to the total landings of sampled vessels by size grade, and secondly, to the monthly total landings in a given port. Even though the port sampling programme covers counties Dublin, Wicklow and Wexford, the analysis presented in the following section were only implemented for harbours Arklow, Courtown (including Cahore Point) and Wicklow (including Greystones). Geographically, these harbours and the sea area fished by vessels using these ports, are in close proximity, and historically they have accounted for most of the landings in area (Figure 84).

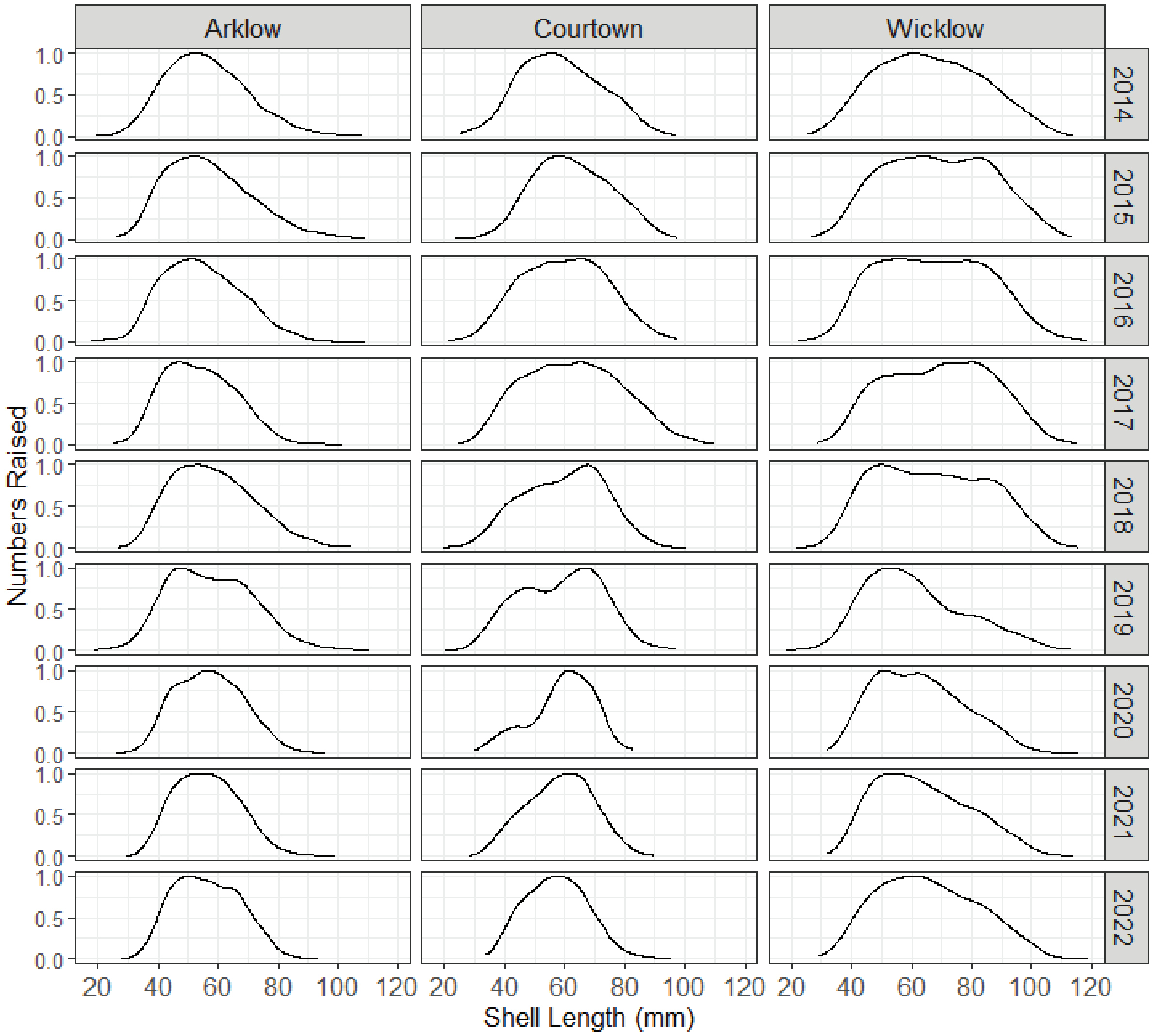


Figure 88. Whelk size distribution at harbour level from port sampling data raised to the total landings. Number of whelk measured presented in a scale from 0-1 for visualization.

13.3 *Stock Assessment*

Previous assessment of whelk in the area was carried out in the early 2000's (Fahy et al., 2000). A Yield Per Recruit (YPR) model, based on the raised port sampling data was used to identify growth overfishing YPR reference points. Fishing mortality over the time series was then estimated using the length-converted catch curve method to assess the relative status of whelk against these YPR reference points. The YPR model focuses on the relationship between the size of the fish at the time of capture and the potential yield obtained per individual fish over its lifetime (the recruit). This model aims to find an optimal balance between harvesting fish at a given size and fishing mortality rate against the growth rate and natural mortality rate that maximizes the yield. The YPR model requires estimates for growth rate of the stock under consideration. A review and re-estimation of growth parameters for selected harbours is presented below.

13.3.1 Growth rate parameters

Growth parameters were estimated by fitting von Bertalanffy growth equation to the observed mean length at age:

$$L_t = L_\infty(1 - e^{[-K(t-t_0)]})$$

Where L_t is the length at age at time t, L_∞ is the theoretical maximum length, t_0 is the theoretical age at length zero and K is the growth coefficient. Whelk age was historically determined by counting the number of rings on the surface of the operculum. This methodology was later found to have limited success in contrast with the novel statolith age determination technique (Hollyman *et al*., 2018). In the current assessment growth parameters were estimated using revised optimization tools for the Electronic LEngth Frequency ANalysis (ELEFAN) method (Mildenberger *et al*., 2017). The ELEFAN method estimates growth parameters by tracking progression in the modal size (representing putative cohorts or age classes) of whelk over time. This method is known to be sensitive to user inputs that are used to define cohorts in the length frequency data, in particular the moving average (MA) setting (Taylor & Mildenberger, 2017; Gayanilo & Pauly, 1997). To assess the effect in the fitted growth curves, the ELEFAN approach was fitted over the port sampling data under different MA setting (5, 7, 9, 11). Additionally, for each MA setting, 500 bootstraps, with re-sampling, were estimated to assess the uncertainty in growth parameters. Results are provided at harbour level (Arklow, Courtown, Wicklow), as well as at region level (grouping all harbours data), to assess the effect of spatial aggregation on growth parameters.

Bootstrap parameter estimates for each MA setting and harbour are displayed in Figure 89 and Figure 90. The expected negative correlation between K and $\boldsymbol{L_\infty}$ across areas is evident when comparing different MA settings (increasing MA setting results in increasing K and decreasing $\boldsymbol{L_\infty}$). There are significant differences in parameter estimates across MA settings for each area. Uncertainty within given MA settings (width of each box; Figure 89) is substantial in harbours Courtown and Arklow, but is considerably smaller in Wicklow harbour. Several potential combinations of $\boldsymbol{L_\infty}$ and K were found in harbours Arklow and Courtown, dependent on the MA setting chosen, whereas Wicklow displays similar combinations of life-history parameters across MA settings (Figure 89). When all harbours combined, bootstrap estimates in MA settings 7, 9, 11 have converged in only a few parameter estimates. After visualization of resulting growth curves from the combination of life-history parameter estimates, and based on previously reported $\boldsymbol{L_\infty}$ and K, for the area the most likely MA setting for the available data was MA=5 for individual harbours and MA=7 for all harbours combined. Median parameter estimates under each chosen MA setting are shown in Figure 90 and Table 30. Parameter estimates from the length-weight relationship ($\boldsymbol{W = aL^b}$ a=0.203, b=2.752) were also estimated for all harbours combined.

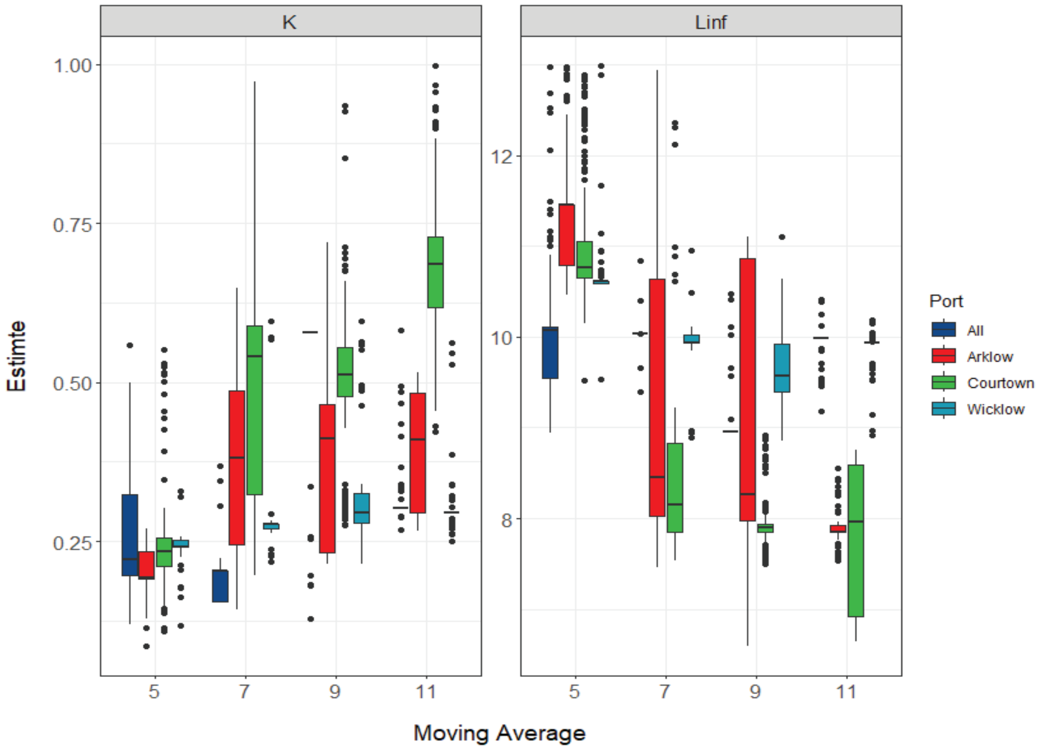


Figure 89. Bootstrap estimates for K (growth coefficient) and L_∞(asymptotic length in millimetres) under different MA settings (x-axis), for "All" Wicklow harbours, and by individual harbours.

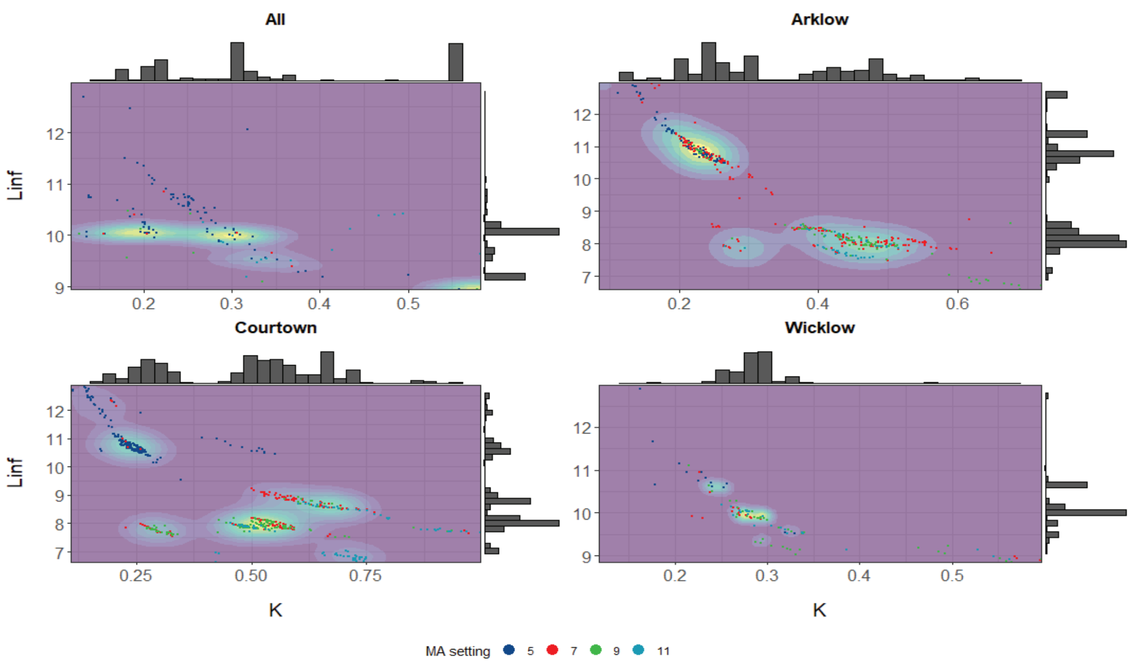


Figure 90. Two-dimension kernel density plot displaying the most likely combination of L_{inf} (y-axis) and K (x-axis). Colour of the points defines the MA setting input. Background colour intensity reflects most likely combination of life-history parameters by overlapping each parameter estimate histogram.

Table 30. Whelk Life history parameters in the 2000's assessment compared to parameters estimated in this report (2023). The 2023 estimates are median parameter values under MA setting 5 (for individual harbours) and 7 (for all harbours combined), after visual inspection and selection of best fitting growth curves. *1: In 2000's assessment, "All" includes the whole Irish Sea while in 2023, it only includes Arklow, Courtown and Wicklow harbours. *2: In 2000's assessment, the Arklow area, also included the landings from Wicklow harbour.

Area	Year	L_∞(mm)	K
All	2000	106	0.13
	2023	100.3	0.2
Dublin	2000	101.6	0.19
	2023	-	-
Wicklow	2000	-	-
	2023	106.2	0.24
Arklow	2000	107	0.15
	2023	114.5	0.19
Courtown	2000	116.1	0.1
	2023	107.6	0.23
Wexford	2000	105.5	0.15
	2023	-	-

13.3.2 Thompson and Bell – Yield Per Recruit Model

Using the growth parameters estimated above a YPR model was applied over the available time series (2014-2022) to define reference points. Bootstrapped life-history parameter estimates under different MA settings presented in the previous sections were used which allowed an assessment of the influence of growth parameters in the YPR model estimates. By default, the YPR model assumes knife-edge selectivity (full selectivity and constant fishing mortality across size classes above the length at first capture). However, there were indications of "dome-shaped" selectivity. This selectivity pattern was also found in recent studies in whelk pot selectivity (Colvin et al., 2024 – submitted). For these reasons, a vector of fishing mortality per length class was estimated using the length-converted cohort analysis (LCCA; Jones R., 1984). Total mortality (Z) over three-year periods (2014-2016; 2017-2019; 2020-2022) was estimated using the LCCA method using the port-sampling length frequency data and natural mortality of M=0.2 year^{-1}. Life-history parameters resulting in aberrant YPR model estimates were removed.

Current fishing mortality levels (F_{cur}) estimated from the length converted catch curves were compared against two commonly used reference points F_{max} and $F_{0.1}$. F_{max} is the "level of fishing mortality for a given size at first capture, which maximizes the average yield from each recruit entering the fishery", while $F_{0.1}$ is the "fishing mortality rate at which the slope of the yield per recruit curve, as a function of fishing mortality, is 10 % of its value at the origin" (Gulland & Boerema, 1973). $F_{0.1}$ is regarded as more precautionary (Clark, 1991). For all harbour levels, reference point estimates across the 9 years and MA settings were similar (figure not shown), so the median value of F_{max} and $F_{0.1}$ were used (Table 31).

Table 31. Reference points median value at harbour level.

Port	F_{max}	$F_{0.1}$
All	0.561	0.351
Arklow	0.621	0.361
Courtown	0.681	0.381
Wicklow	0.561	0.351

Figure 91 displays the percentage of bootstraps where the current fishing mortality (F_{cur}) is above F_{max} and $F_{0.1}$, for all harbours under different MA settings. Across MA settings, over 50 % of F_{cur}bootstrap estimates for Arklow and Courtown are above $F_{0.1}$, and in many scenarios close to or above F_{max}. In comparison, Wicklow F_{cur} bootstrap estimates are well below reference points. When all harbours are combined the estimates vary substantially across MA settings suggesting that the level of spatial aggregation produces different F_{cur} estimates. Results from the catch curve bootstraps estimates applied over three-year periods (Figure 92) shows a clear increase in F_{cur} in Wicklow harbour across MA settings, exceeding $F_{0.1}$ in 2020-2022. This is also evident in Arklow harbour, except in MA=11. Courtown shows a reduction in F_{cur} in 2017-2019, followed by an increase in the later period. Figure 93, shows the YPR curves resulting from the bootstraped life-history parameters, and highlighted in black the YPR curve and F_{cur} (black dot) estimated from the median values of L_∞ and K under MA=5.

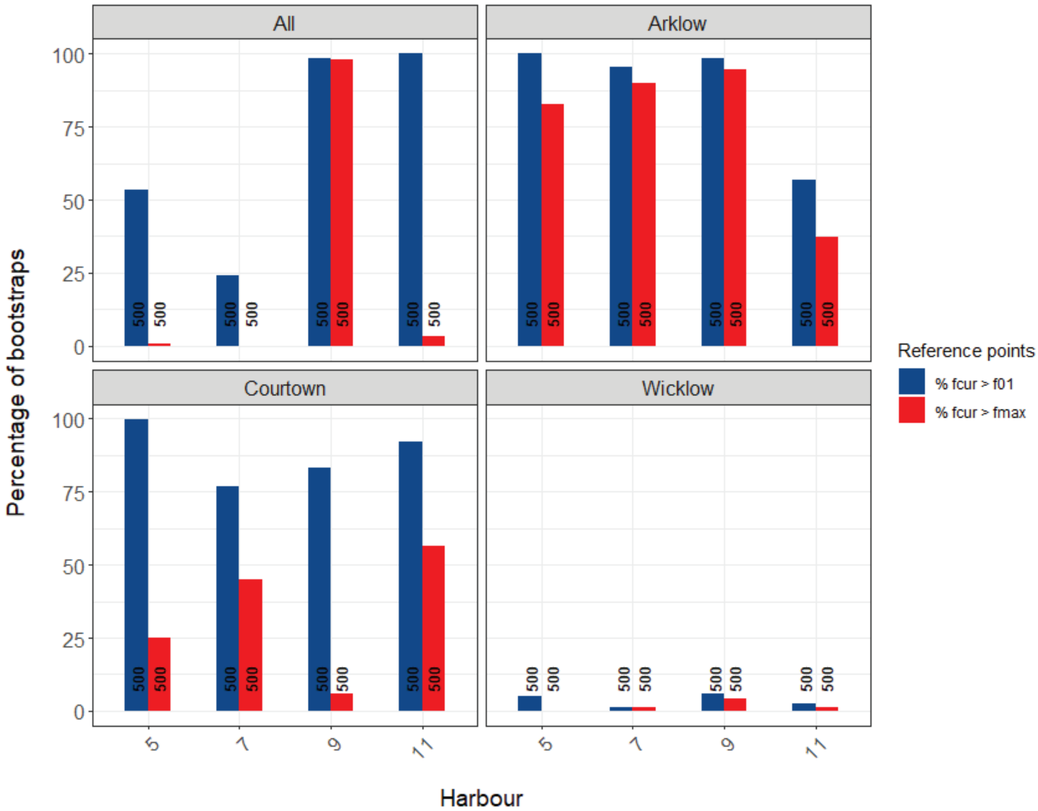


Figure 91. Percentage of bootstraps in which F_{cur} is above F_{01} (blue bars) or above F_{max} (red bars) for each harbour across MA settings. Number of bootstraps considered indicated at the bottom of each bar.

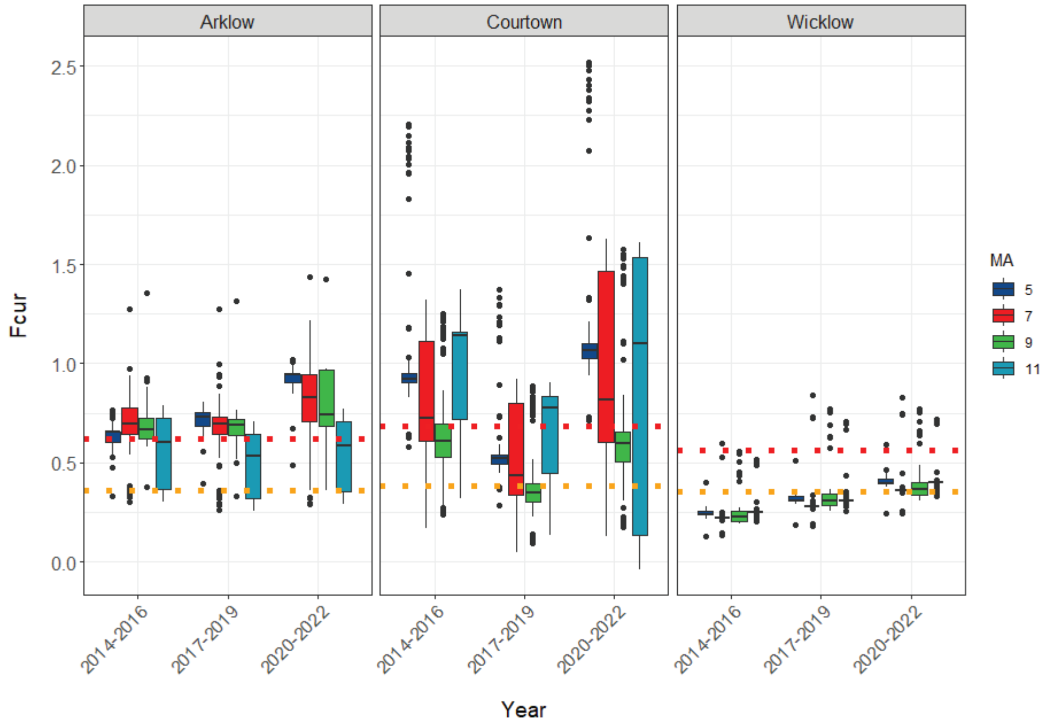


Figure 92. F_{cur} bootstrap estimates in three-year periods at harbour level under different MA settings. F_{01} and F_{max} included as orange and red dotted lines respectively.

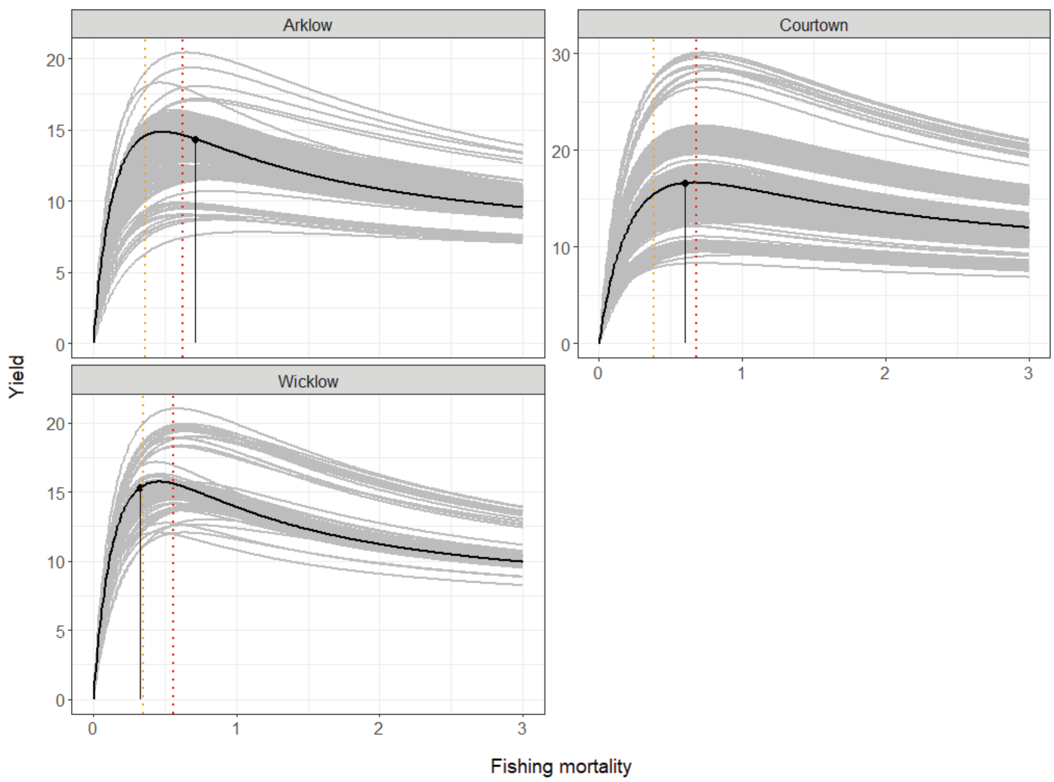


Figure 93. YPR curves resulting from bootstrapped life-history parameter estimates under four different MA settings (grey) and YPR curve and F_{cur} resulting from the median values of L_∞ and K under MA=5 (black). F_{01} and F_{max} at harbour level in orange and red respectively.

13.4 *Conclusion*

Landings of whelk per unit effort between 2014-2022 were stable but clearly lower when compared to 2006-2008. Total landings in Co. Wicklow and Co. Wexford have been stable since 2014, but a clear decrease has occurred in Co. Dublin.

Re-estimation of growth parameters, from port sampling data, correspond with previous parameter estimates reported. Nevertheless, there is significant uncertainty including spatial differences around growth parameters, which has an important effect on estimation of reference points and current fishing mortality rates. Fishery management reference points (F_{max} and F_{01}), were derived using a combination of methods to assess the status of whelk in the area relative to current fishing mortality rates. These reference points identify the fishing mortality rates that optimise yield per recruit and to identify mortality rates that would avoid growth overfishing.

Across scenarios tested, and accounting for the uncertainty in life-history parameters, outputs suggest that current fishing mortality is above reference points and suggest growth overfishing in sea areas fished by vessels using Arklow and Courtown harbours. For Wicklow Harbour fishing mortality is increasing and is close to the reference points. A reduction in fishing mortality rates is, therefore, advised. This advice is also consistent with the observed decline in catch rates since 2006-2008 and given that the size at maturity is likely to be well above the MLS.

The main sources of uncertainty in this assessment framework include the potential mix of whelks in a given harbour coming from different sea areas (which may have different growth rates), the estimation of life-history parameters without reliable age data, and the chosen value of natural mortality ($M=0.2$ year^{-1}) which directly scales up or down fishing mortality estimates. The landings of whelk before 2014 were substantially lower than in the time period analysed in this report. The current assessment would be improved, therefore, by including data prior to 2014 to assess fishing mortality estimates under previous exploitation rates. In addition, spatial mapping of fishing activity would allow changes in fishing effort and location to be identified and local depletion or sequential depletion of whelk in different areas of ground to be identified. This fishing pattern could lead to hyperstability in the LPUE index.

14 References

Caddy, J.F. 1989. Recent developments in research and management for wild stocks of bivalves and gastropods. Marine Invertebrate Fisheries. Their assessment and management. Ed. J.F. Caddy. New York: John Wiley and Sons.

Clark, W.G. 1991. Groundfish exploitation rates based on life history parameters. *Canadian Journal of Fisheries and Aquatic Sciences*, *48*(5), pp.734-750.

Fahy, E., Yalloway, G and Gleeson, P. 1995. Appraisal of the whelk *Buccinum undatum* fishery of the Southern Irish Sea with proposals for a management strategy. Irish Fisheries Investigation, Series B No. 42, Department of the Marine.

Fahy, E., Masterson, E., Swords, D. and Forrest, N. 2000. A second assessment of the whelk fishery *Buccinum undatum* in the southwest Irish Sea with particular reference to its history of management by size limit. Marine Fisheries Services Division. Marine Institute, Abbotstown, Castleknock, Dublin 15.

Gayanilo, F.C. and Pauly, D. 1997. FAO-ICLARM stock assessment tools Reference manual stock assessment tools Reference manual. 262.

Gedamke, T. and Hoeing, J. 2006. Estimating mortality and mean length data in nonequilibrium situations, with application to the assessment of goosefish. Transactions of the American Fisheries Society 135(2): 476-487.

Gulland, J.A. and Boerema, L.K. 1973. Scientific advice on catch levels. Fish. Bull. 71(2): 325–335.

Hollyman, P. R., Chenery, S. R. N., Leng, M. J., Laptikhovsky, V. V., Colvin, C. N. and Richardson, C. A. 2018. Age and growth rate estimations of the commercially fished gastropod *Buccinum undatum*. ICES Journal of Marine Science, doi: 10.1093/icesjms/fsy100.

Huynh, Q. C., Beckensteiner, J., Carleton, L. M., Marcek, B. J., Nepal, V. KC, Peterson, C. D., Wood, M. A. and Hoenig, J. M. 2018. Comparative performance of the Three Length-Based Mortality Estimators. Marine and Coastal Fisheries 10(3): 298-313.

Jones, R. 1984. Assessing the effects of changes in exploitation pattern using length composition data (with notes on VPA and cohort analysis). *FAO Fisheries Technical Paper*, no. 256: 118p.

King, M. 1995. Fisheries Biology, Assessment and Management. Fishing News Books, Oxford.

Mildenberger, T.K., Taylor, M.H. and Wolff, M. 2017. TropFishR: an R package for fisheries analysis with length-frequency data. *Methods in Ecology and Evolution*, *8*(11), pp.1520-1527.

Pauly, D. 1983. Length-converted catch curves: a powerful tool for fisheries research in the Tropics (part 1). Fishbyte, The WorldFish Centre 1(2): 9-13.

Taylor, M.H. and Mildenberger, T.K. 2017. Extending electronic length frequency analysis in R. *Fisheries Management and Ecology*, *24*(4), pp.330-338.

15 Glossary

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

Benthic living in or relating to the lowest levels of the sea and sea floor.

***Bonamia* (*ostreae*)** 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.

Bivalve 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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