Shellfish Stocks and Fisheries

Review 2014

An assessment of selected stocks

The Marine Institute and Bord Iascaigh Mhara

Bord Iascaigh Mhara
Irish Sea Fisheries Board

Marine Institute
Foras na Mara

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1 Introduction

This review presents information on the status of selected shellfish stocks in Ireland. In addition, data on the fleet (<13 m) and landings for all species of shellfish (excluding *Nephrops* and mussels) are presented. The intention of this annual review is to present stock assessment and scientific advice for shellfisheries which may be subject to new management proposals or where scientific advice is required in relation to assessing the environmental impact of shellfisheries especially in areas designated under European Directives. The review reflects the recent work of the Marine Institute (MI) in the biological assessment of shellfish fisheries.

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. In particular a number of shellfish fisheries are now under Natura 2000 site management regimes.

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

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

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

The main customers for this review are DAFM the RIFFs, NIFF, DCENR and IFI.

2 Shellfish Fleet

2.1 Fleet capacity

The total registered capacity of the Irish fishing fleet, as of November 20th 2014, was 63,112 gross tonnes (GTs) and 2,124 vessels. The polyvalent general segment is the largest and includes 31,771 GTs and 1,407 vessels. The polyvalent potting segment has 448 registered vessels and 946 GTs.

2.2 Fleet structure

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

(1) Polyvalent [Potting] Sub-segment; vessels of <12 m length overall (LOA) fishing exclusively by means of pots. Such vessels are also <20 GT. Target species are crustaceans and whelk.

(2) Polyvalent [Scallop] Sub-segment; vessels ≥10 m LOA with the required scallop (*Pecten maximus*) fishing history. These vessels also retain fishing entitlements for other species excluding those listed in Determination No. 21/2013.

(3) Polyvalent [<18 m LOA] Sub-segment; Vessels with fishing entitlements for a broad range of species other than those fisheries which are authorised or subject to secondary licencing as listed in Determination No. 21/2013 (http://agriculture.gov.ie/fisheries/).

(4) Polyvalent [≥18 m LOA] Sub-segment; Vessels with fishing entitlements for a broad range of species other than those fisheries which are authorised or subject to secondary licencing as listed in Determination No. 21/2013.

The **Specific Segment**, which entitles vessels to fish for bivalves only, is divided into the following two Sub-segments;

(1) Specific [Scallop] Sub-segment for vessels ≥10 m LOA with the required scallop (*Pecten maximus*) fishing history;

(2) Specific [General] Sub-segment for all other Specific vessels irrespective of LOA.

The size distribution of vessels in the polyvalent segment of the fleet is approximately tri-modal (Figure 1); the bulk of vessels are between 3 m and 10 m in length. These are typical open or half-decked traditional fishing vessels fishing seasonally in coastal waters. There is a smaller peak of vessels between 8-10 m and to a lesser extent between 10-12 m; there is a break in the size distribution at 14-16m with only 8 vessels in this category.

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. This applies to over 18m and under 18m sub-segments.

(2) Excluding the fisheries listed in Determination No. 21 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 and to fish for species other than those in Determination No. 21 but are governed by TAC & Quota and any other harvest control rules that might generally apply.

(3) In the case of fisheries listed in Determination No. 21 the authorisation to fish such stock 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 is assigned.

(5) Polyvalent general capacity that is not attached to a registered vessel for a period of more than 2 years expires.

(6) When polyvalent potting capacity is no longer attached to a registered vessel then the capacity reverts to the licencing authority. This capacity is not re-issued. In 2013 6% of this capacity was transferred to first degree relatives

2.4 *Vessels targeting Shellfish*

The shellfish fleet can usefully be defined as vessels under 13 m in length as the vast majority of such vessels depend largely on shellfish. This cut off, however, is not reflective of any licencing or policy condition. In addition 2 vessels over 18 m target crab mainly in offshore waters (vivier vessels) and 9 vessels over 13 m in length were authorised to fish for scallops in 2014.

The number of vessels in the Shellfish fleet increased by 64% between 2006 and 2012 (Table 2, Table 3). This was predominantly due to regularisation of the potting fleet which were operating outside of the registered fleet prior to 2006 and to registration of existing vessels operating dredges in fishery order and aquaculture licensed areas. The number of vessels in the polyvalent potting segment is declining by on average 6 vessels per year, due to de-registration or transfer from this restricted segment, which limits fishing entitlement. The number of vessels in the polyvalent general segment increased year on year between 2007 and 2012 by an average of 63 vessels per year. This trend was reversed in 2012-2014 during which time there was an average reduction of 26 vessels per annum. The number of vessels in the specific segment declined by an average of 5 vessels per year from 2009-2014 despite significant increases in fishing activity in some bivalve fisheries.

The average length and capacity of vessels in the polyvalent and specific segments declined between 2006 and 2014. Polyvalent vessels under 13 m in length were on average 0.7 GT smaller in 2014 compared to 2007.

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

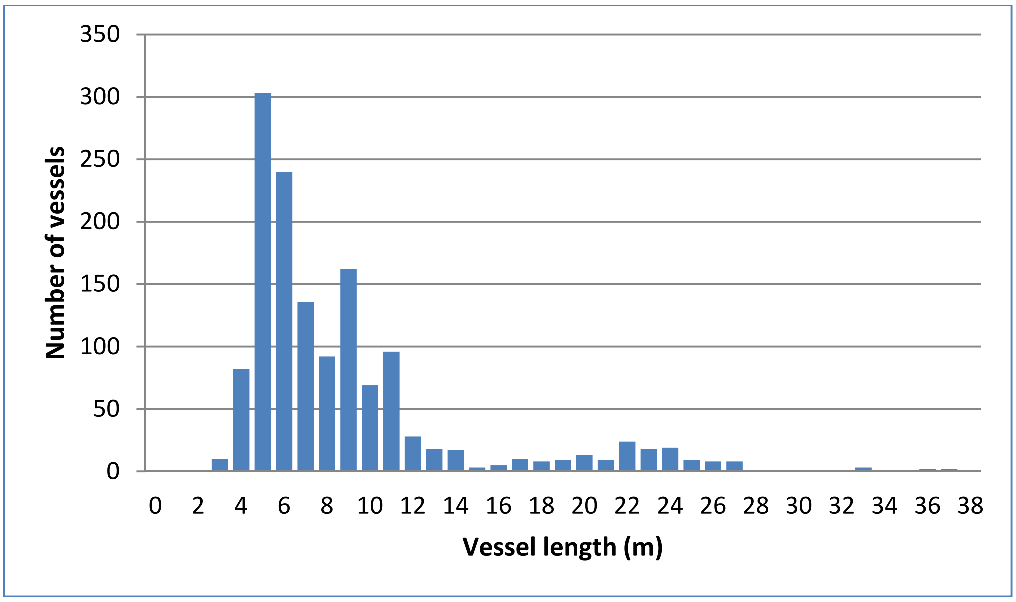

Figure 1. Vessel length distribution in the Irish fishing fleet in November 2014.

Table 1. Capacity (GTs) of Irish fishing fleet segments and sub-segments in November 2014.

		Gross tonnage				
Segment	Vessels	Total	Mean	S.d.	Min	Max
Aquaculture	107	4576	42.8	110.5	0.15	561.0
Beamer	11	1023	93.0	43.7	1.10	161.0
Pelagic	23	22624	983.7	473.2	256.00	1988.0
Polyvalent General	1407	31771	22.6	58.7	0.19	518.0
Polyvalent Potting	448	946	2.1	2.3	0.31	18.3
Specific	128	2172	17.0	32.2	1.39	187.0
Total capacity	**2124**	**63112**				

Table 2. Length and capacity profile of the Irish Shellfish fleet 2006-2014 (<13 m polyvalent, all polyvalent potting, all vessels in specific segment, all aquaculture vessels). Two >18 m crab vivier vessels not included.

Segment	2006	2007	2008	2009	2010	2011	2012	2013	2014
Aquaculture	16	21	39	73	86	96	104	86	89
Polyvalent General	953	950	994	1131	1198	1257	1269	1233	1216
Polyvalent Potting	80	492	490	481	467	461	460	454	448
Specific	157	117	128	154	150	145	148	137	128
Grand Total	1206	1580	1651	1839	1901	1959	1981	1910	1881
Average length of vessels									
Aquaculture	31.62	30.00	21.51	14.75	13.33	12.78	12.46	7.14	7.15
Polyvalent General	7.95	7.89	7.82	7.67	7.57	7.63	7.51	7.50	7.52
Polyvalent Potting	7.32	6.74	6.76	6.71	6.67	6.64	6.62	6.62	6.62
Specific	14.70	13.40	13.22	12.09	12.06	11.71	11.58	11.46	11.23
Average Gross Tonnage of vessels									
Aquaculture	212.05	197.86	117.30	64.18	54.12	48.87	45.64	2.71	2.72
Polyvalent General	4.68	4.61	4.38	4.14	3.96	4.30	3.85	3.87	3.91
Polyvalent Potting	2.96	2.28	2.30	2.22	2.16	2.12	2.10	2.11	2.11
Specific	38.62	27.34	25.93	20.54	20.29	18.55	18.25	17.93	16.97
Average kilowattage of vessels									
Aquaculture	468.55	433.79	284.45	166.11	142.51	132.04	126.74	32.48	32.11
Polyvalent General	35.49	36.46	34.22	31.91	30.61	31.88	29.79	29.61	30.17
Polyvalent Potting	44.50	29.60	30.29	29.70	28.93	28.28	28.03	28.06	28.23
Specific	162.81	124.53	114.15	96.99	94.26	90.32	90.28	88.62	85.79
Kilowatts per GT									
Aquaculture	2.21	2.19	2.42	2.59	2.63	2.70	2.78	11.98	11.81
Polyvalent General	7.58	7.91	7.81	7.72	7.74	7.42	7.73	7.65	7.71
Polyvalent Potting	15.03	12.99	13.20	13.39	13.41	13.32	13.35	13.32	13.37
Specific	4.22	4.56	4.40	4.72	4.65	4.87	4.95	4.94	5.06

Table 3. Annual percentage change in numbers of vessels per fleet segment in the Shellfish fleet 2006-2012.

Segment	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014
Annual change in number of vessels								
Aquaculture	5	18	34	13	10	8	-18	3
Polyvalent General	-3	44	137	67	59	12	-36	-17
Polyvalent Potting	412	-2	-9	-14	-6	-1	-6	-6
Specific	-40	11	26	-4	-5	3	-11	-9
Annual % change in number of vessels								
Aquaculture	31.25	85.71	87.18	17.81	11.63	8.33	-17.31	3.49
Polyvalent General	-0.31	4.63	13.78	5.92	4.92	0.95	-2.84	-1.38
Polyvalent Potting	515.00	-0.41	-1.84	-2.91	-1.28	-0.22	-1.30	-1.32
Specific	-25.48	9.40	20.31	-2.60	-3.33	2.07	-7.43	-6.57

3 Landings 2005-2014

Annual landings of crustaceans and bivalves, excluding *Nephrops* and wild blue mussel (*Mytilus*) seed, which is re-laid for on-growing, during the period 2005-2014, varied from a high of 18,500 tonnes in 2005 to a low of 13,790 in 2009 (Table 4).

Landings data for some species (lobster, periwinkle) in recent years show unexplained changes in volumes relative to say 2004 levels. Spider crab in 2012 was substantially higher than in any previous years. Brown crab landings in 2012 were less than half of their value in 2004. Lobster landings in 2012 were approximately 30% of 2011 landings. Although landings can obviously increase or decline due to changes in effort or catch rates the scale of change in some species, the fisheries that are known to have stable or increasing effort and where catch rate indicators are stable, is contradictory. Other sources of information from industry questionnaires also indicate significant differences between official landings and landings derived from estimates of catch rates, annual individual vessel landings, days at sea and individual vessel fishing effort. There is also poor correspondence between sales note data and landings reported in EU logs combined with estimates for under 10 m vessels which do not report catch and effort.

A number of species such as lobster, periwinkle, native oyster and shrimp are targeted by vessels under 10 m in length. As these vessels do not report landings capturing these data is difficult due to the large number of vessels and the small daily consignments involved. Improved tracking of landings by vessels under 10 m would significantly improve data on total landings for a number of species and give a more accurate picture of the economic value of the shellfisheries sector.

Landings data for certain species that are subject to management plans (cockle), that are managed locally (oysters) or where SFPA have analysed gatherers dockets and consignment data to buyers (razor clams) are accurate.

In 2013 the most important species in terms of value were scallop, brown crab, lobster, whelk, shrimp and razor clams.

Table 4. Estimates of annual landings (tonnes) and value (€) of crustacean and bivalve shellfish (excl. prawns and mussels) into Ireland 2005-2014 (source: SFPA, logbooks). Unit value (per kilo) is from sales note data or other sources. * from www.sfpa.ie. Estimates for 2014 not available at time of writing other than for species presented.

Scientific Name	Common name	2005	2006	2007	2008	2009	2010	2011	2012	2013	*2014*	2013 (2014 where available)	
												Unit Price	Value
Cancer pagurus	Edible crab	9,527	10,827	9,251	7,640	6,614	8,622	6,372	6,691	**6,510***		€1.49	€9,699,900
Pecten maximus	King Scallop	1,277	742	953	1,322	1,207	1,982	2476	2,703	**2,584***		€5.90	€15,245,600
Homarus gammarus	Lobster	635	625	308	498	431	477	735	249	374		€12.72	€4,757,280
Littorina littorea	Periwinkle	1,139	1,210	609	1,141	1,103	1,280	64	103	218		€2.04	€444,720
Buccinum undatum	Whelk	4,151	3,144	3,635	1,947	2,239	2,976	2,828	3,440	2,660		€1.20	€3,192,000
Palaemon serratus	Shrimp	151	319	325	180	228	135	111	152	157		€16.43	€2,579,510
Ostrea edulis	Native oyster	94	233	291	88	327	349	100	*100*	214	300	*€4.00*	€1,200,000
Aequipecten opercularis	Queen scallop	75	172	26	4		748	1,002	1,479	285		€1.70	€484,500
Necora puber	Velvet crab	245	281	142	268	205	342	160	168	365		€1.99	€726,350
Spisula	Surf clam		26	14	55	150	*162*	*73*	15	37	*49*	€3.00	€147,000
Maja brachydactyla	Spider crab	141	153	70	153	443	415	290	818	229		€1.08	€247,320
Palinurus elephas	Crayfish	30	34	16	18	28	30	25	33	34		€35.00	€1,190,000
Ensis spp	Razor clams	413	547	466	480	293	590	636	498	723	917	€3.54	€3,246,180
Chaceon affinis	Red crab	294	152	83	44	105	91	106	0	0	*0*		€0
Carcinus maenas	Shore crab	27	46	91	72	244	129	74	253	31		€0.62	€19,220
Cerastoderma edule	Cockle	107	7	643	9	173	5	401	400	374	*0*		€0
Veneridae	Venus clam	217	4										
Total		**18,514**	**18,522**	**16,813**	**13,890**	**13,790**	**17,874**	**15,415**	**16,722**	**16,722**			**€43,179,580**

4 Surf clam (*Spisula solida*)

4.1 Management advice

The Waterford estuary surf clam stock is assessed by annual survey and retrospective analysis of LPUE data. Mean annual LPUE was stable in the period 2009-2014 although in season depletion was evident especially in 2014. Recruitment to the stock is episodic.

TAC has been agreed on a voluntary basis since 2010 at 33% of biomass. This should continue but take into account the absence of regular recruitment into the stock. The LPUE data time series should be continued as the dredge efficiency in the survey is unknown and biomass estimates are uncertain.

There are no input or output controls in place for other surf clam stocks.

4.2 Issues relevant to the assessment of the surf clam fishery

The spatial extent of surf clam beds is very limited and the species requires particular substrates of coarse sand. There are at least 6 surf clam beds around the coast but not all are fished.

The species is relatively slow growing and long lived. Recruitment appears to be highly variable and the fishery may rely on strong year classes recruiting periodically into the stock. Year on year depletion of biomass, due to fishing mortality, may occur especially if there is no recruitment for a number of years.

Fishery independent survey estimates and age disaggregated catch rate data can provide indicators of trends in stock, biomass and recruitment. Provision of catch and effort data by industry is good and has been a legislative requirement in some cases. This, together with local TAC agreements, has improved the management of the fishery compared to historic 'boom and bust' scenarios.

4.3 Management Units

Surf clam beds exist as discrete locally distributed populations with specific substrate (coarse sand, gravel) requirements. A number of beds exist around the coast; Waterford Harbour, Youghal, at the Sovereign Rocks in Cork, south east Galway Bay, Kilkieran Bay, Clifden and Iniskea Island in Mayo. The Waterford Harbour, Clifden and Galway Bay stocks are exploited more frequently than the others. Each clam bed can be treated as a separate management unit.

4.4 Management measures

A voluntary annual TAC of 33% of biomass is in place for the Waterford fishery. Biomass is estimated by annual survey. Minimum landing size is 25 mm. Individual vessels cannot land more than 2 tonnes per day. Fishing is limited to 5 days per week and between 07:00 and 13:00 hours each day. Clams must be landed to designated ports of Dunmore East or Duncannon. The intention to fish and the landing port used has to be notified to the SFPA 48 hours prior to fishing (S.I. 221/2011).

4.5 *Waterford estuary*

4.5.1 Survey methods

A commercial box dredge (with 12 mm bar spacing) is deployed to collect samples in a predetermined 100 m x 100 m survey grid across the clam ground. Tow length is approximately 50-70 m. Oyster trestle bags, with a 4-9 mm mesh, are used to cover the dredge to retain all clams (undersized as well as commercial sized) in the dredge.

Dredge efficiency is unknown.

4.5.2 Biomass 2013 and 2014

The biomass in the survey area (0.32 km^2) in the Waterford estuary in March 2013 was 65 tonnes. In March 2014 the biomass in the survey area (0.30 km^2) was 91 tonnes (Figure 2). The survey area in 2012 was 0.79 km^2 which better defines the spatial limits of the stock. Raising the 2013 and 2014 surveys to the 2012 survey area provides total biomass estimates of 160 and 237 tonnes respectively. These estimates assume a dredge efficiency of 100% which is unlikely and are therefore highly likely to be underestimates of total biomass. TACs for 2013 and 2014 were advised as 53 tonnes and 79 tonnes respectively or 33% of biomass.

Mean density (m^{-2}) of clams in the surveys, assuming 100% dredge efficiency, has been relatively stable since 2010 varying between 0.14 in 2010 to 0.41 in 2012 (Table 5**).**

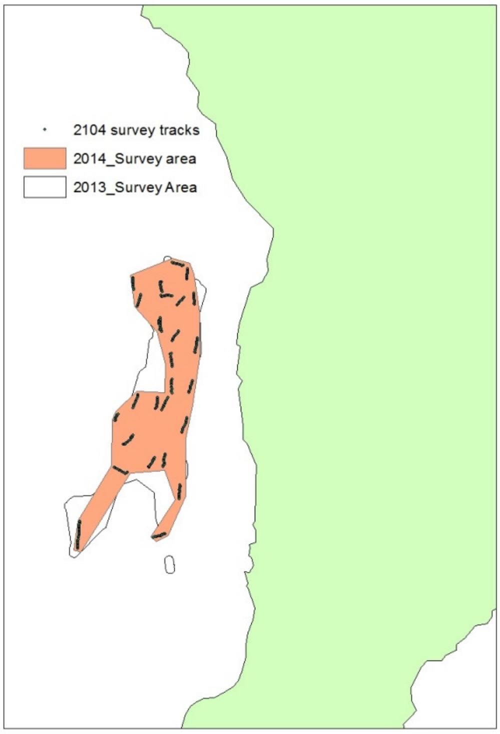

Figure 2. Areas of the Waterford surf clam bed surveyed in 2013 and 2014 (including survey tracks).

Table 5. Annual mean density (m^{-2}) of clams in the Waterford estuary assuming 100% dredge efficiency.

		Density		
Year	**N**	**Mean**	**S.d.**	**Max**
2009	26	1.093	1.039	3.576
2010	45	0.143	0.215	1.014
2011	38	0.220	0.267	1.064
2012	62	0.416	0.662	3.551
2013	31	0.195	0.275	1.039
2014	27	0.303	0.306	0.968

4.5.3 Size and age composition 2009-2014

Age composition data from the Waterford Surf Clam bed suggests that recruitment to the clam bed may be irregular with strong and weak year classes. The age composition was dominated by 3+ year old clams in 2009 and 4+ clams in 2010. Four year olds also dominated in 2011, to a lesser extent, with the second highest proportion being 5+. In 2012 5+ year olds were predominant and 83.9% of the clams were ≥25mm in shell length. The modal shell length in 2012 was 35 mm.

From the 2013 survey the modal shell length was smaller at 27 mm and the majority (28%) of the clams aged were 2+ year olds, indicating that the smaller cohorts of clams identified in 2011 and 2012 were recruiting to the fishery. There was still a high proportion (22%) of 5+ clams recorded during the 2013 survey. In 2014 age ranged from 1-9 years (age of larger clams may be underestimated). Approximately 15% of clams were 1+ and 56% were aged 3-4.

Average shell length declined from 34 mm in 2010 to 28.6 mm in 2012 due mainly to new recruitment and increased to 33 mm in 2014. Few clams less than 20 mm were evident in the 2013 or 2014 surveys (Figure 3, Table 6).

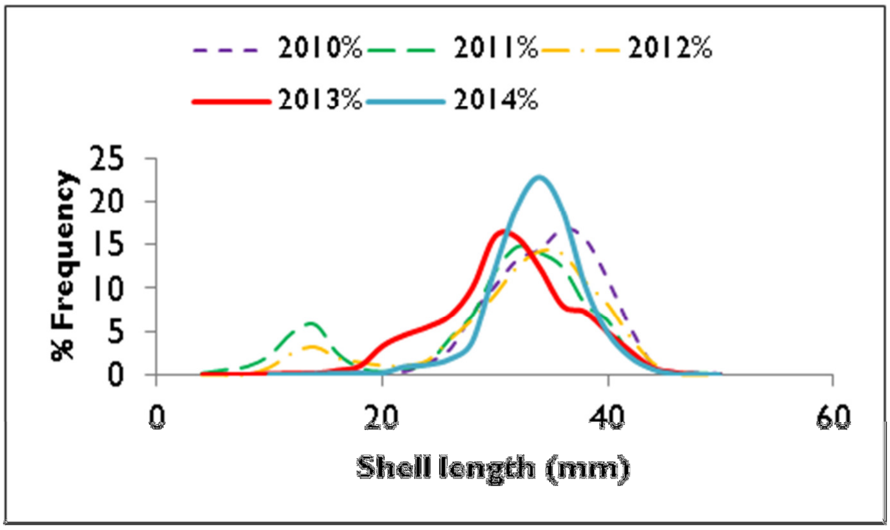

Figure 3. Shell length of surf clams sampled in 2010-2014.

Table 6. Mean shell length of surf clams in annual surveys in Waterford estuary 2009-2014.

		Shell length	
Year	N	Mean	S.d.
2009	1188	31.503	3.863
2010	2721	34.072	4.657
2011	1870	29.341	8.646
2012	2782	28.603	5.967
2013	4081	30.078	5.750
2014	1055	33.100	3.963

4.5.4 Landings and catch rates 2009-2014

Total annual landings in the period 2009-2014 were 39, 162, 73, 49, 36 and 54 (estimate only) tonnes respectively. Some in season depletion in landings per hour was observed in 2009 and 2010 but more significantly in 2014 (Figure 4). The trend in overall landings per hour, from commercial data, declined from 430 to 330kgs.hr^{-1} during 2009-2014.

Although average landings per hour were highly variable within year this was less so in 2013 and 2014 when landings over 500kg.hr^{-1} did not occur. This might indicate fishing down of high density patches of clams or an overall decline in biomass in those years. Pre-season surveys have not detected any decline in density.

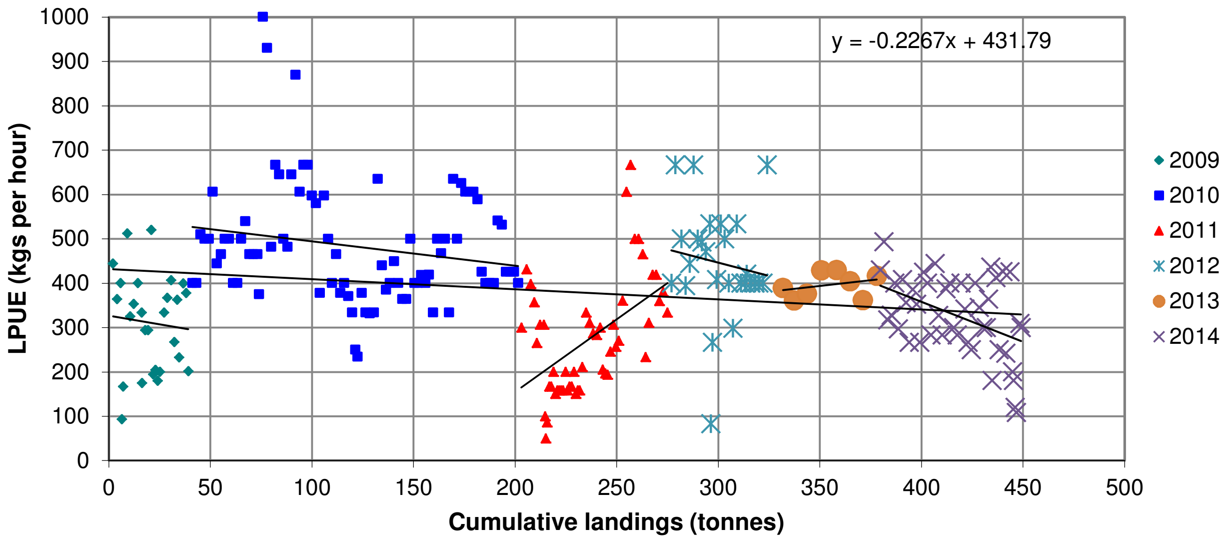

Figure 4. Landing rates (kgs.hr^{-1}) in the Waterford Estuary surf clam fishery in relation to cumulative landings across 2009-2014. In year depletion observed in 2014 and to a lesser extent in 2009 and 2010. Catch rates decline by 0.22kgs per hour per tonne of removal over 6 year period.

Table 7. Annual average landings per hour in the Waterford estuary surf clam fishery 2009-2014.

	LPUE (kgs.hr-1)	
Year	**Average**	**S.d.**
2009	311.10	109.64
2010	483.13	132.99
2011	273.51	129.79
2012	445.33	124.52
2013	396.06	28.13
2014	327.05	88.13

5 Razor clam (*Ensis siliqua*)

5.1 *Management advice*

The razor clam fishery in the north Irish Sea in particular expanded significantly in the period 2011-2014. Landings and effort increased. Although the available data are crude and there are no continuous time series, all indicators (daily landings per vessel, catch per hour, sales note consignment volumes) show a significant and persistent decline over time indicating that the north Irish Sea stock has been and continues to be fished down. Landings per trip and catch per hour indicators suggest that the stock biomass may be 50% of the initial biomass when the fishery began in the late 1990s.

Given the escalation of fishing effort and increased landings, considering the high efficiency of the hydraulic dredge gear, the relatively slow growth of Razor clams and the limited distribution of the stock there is an urgent need to introduce management plans for the fishery. The sustainable catch is significantly lower than the average landings in the past 5 years as these landings have resulted in decline in biomass indicators.

Part of the fishery occurs within Natura 2000 sites in the north and south Irish Sea. The fishery could potentially impact on Common Scoter which feeds on bivalves in shallow water. The conservation objectives for this species and the habitats on which it relies should be integrated into a Razor clam fishery management plan.

5.2 *Issues relevant to the assessment of the razor clam fishery*

Razor clams (*Ensis siliqua*) occur along the east coast of Ireland in mud and muddy sand sediments from Dundalk to Dublin and from Cahore to Rosslare. The distribution is only known from the distribution of the commercial fishery which operates in water depths of 4-14 m. Fishing depth is limited because of the fishing method which uses hydraulically pressurised water to fluidise sediments in front of the dredge. It is likely that razor clam distribution extends to deeper water outside of the range of the fishery as the species occurs at depths of up to 50 m.

The efficiency of the hydraulic dredge used in razor clam fisheries in the UK has been measured at 90%. The dredge, therefore, is very efficient at removing organisms in the dredge track. This is in contrast to non-hydraulic dredges used in other bivalve fisheries such as scallop and oyster where dredge efficiency may be in the region of 10-35%. Selectivity of the dredge is unknown. 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 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.

Physical disturbance of sediments and removal of *Ensis* by the fishery potentially alters the bivalve species composition and generally the faunal communities in benthic habitats. In shallow waters changes in the abundance and species composition of bivalves may have a negative effect on diving seaducks (Common Scoter) that feed on bivalves. This species is designated under the Birds Directive in

Dundalk SPA in Louth and The Raven SPA in Wexford.

5.3 Management Units

Stock structure is unknown. Larval dispersal and movement of juveniles and possibly adults suggests 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. 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.

5.4 Management measures

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

New measures were also proposed by industry in 2014 for the north Irish Sea fishery but have not yet been implemented. These include a weekly quota per vessel of 1.4 tonnes, fishing 6 days per week, reporting GPS position, closure of areas based on catch rate data and closure during the spawning season.

5.5 North Irish Sea

The fishery occurs close to the coast in shallow sub-tidal waters along the east coast from Dundalk south to Malahide (Figure 5). The fishery overlaps with the south part of Dundalk Bay SPA in sub-tidal waters and occurs close to a number of intertidal mud and sand flat SAC designations on the east coast. SPA designations include the Common Scoter which feeds on bivalves in shallow subtidal waters.

Annual landings from the Irish Sea, the bulk of which comes from the north Irish Sea increased to over 900 tonnes in 2014 up from approximately 723 tonnes in 2013. These are the highest annual landings on record. Total fishing effort is unknown but the number of vessels operating in the fishery has escalated significantly since 2012 and by the end of 2014 43 vessels were fishing and a number of others were preparing to fish.

Landings per unit effort (LPUE, kgs.hr^{-1}) were estimated using data from a number of sources including private vessel diaries 2002-2004, from data on consignments to buyers for the period 1998-2004 and more recently (2010-2013) data from sentinel vessel logbooks (Figure 6, Table 8). LPUE in the period 2010-2013 was generally between 20-30 kgs.hr^{-1}. In the period 1998-2004 LPUE was generally 30-50 kg.hr^{-1} and up to 80-100 kgs.hr^{-1} in some areas. Monthly LPUE data from diaries of 2 vessels during 2002-2004 shows significant variability between vessels. LPUE values of 40 kg.hr^{-1} were consistently obtained by 1 vessel while the second vessel showed catch rates which exceeded 120 kg.hr^{-1} in some months (Figure 7).

Declines are also evident in the gatherers docket data (compiled by SFPA Howth) which approximates to landings per vessels per day. In 2013 and 2014 7 and 3% of daily landings, respectively, were over 500 kgs compared to 46% in 2002 (Figure 8). Annual mean landings per trip declined annually from 1999-2013 (Figure 9). Sales note data show an annual decline of 30-50 kgs per vessel per day (Table 9).

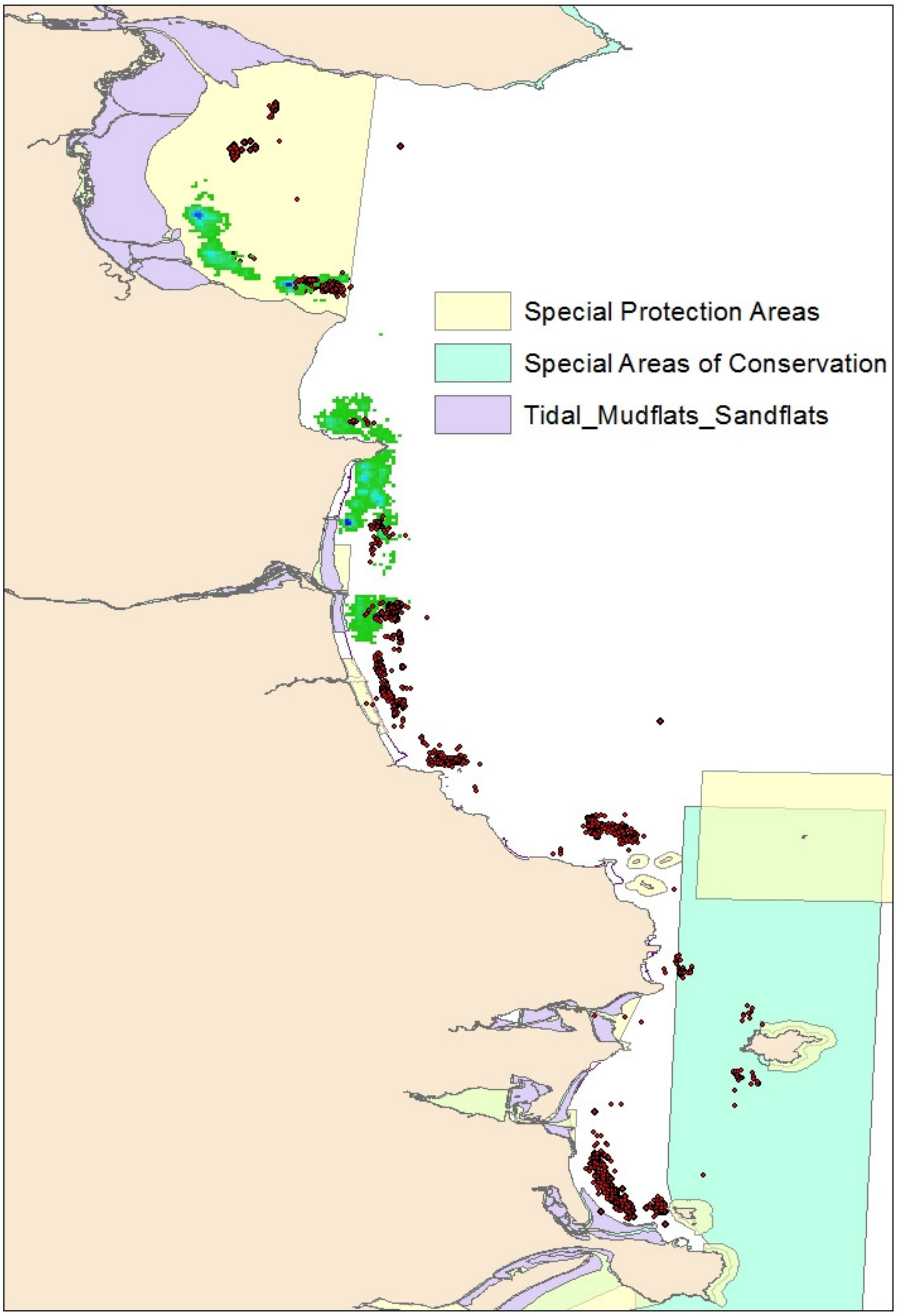

Figure 5. Partial distribution of the fishery for razor clams based on iVMS (2014, shown as green grid) and vessel diary GPS data (2001-2003, shown as points) for a sub-set of the fleet. The location of SPAs and SACs and intertidal mud and sand flats in SACs is shown.

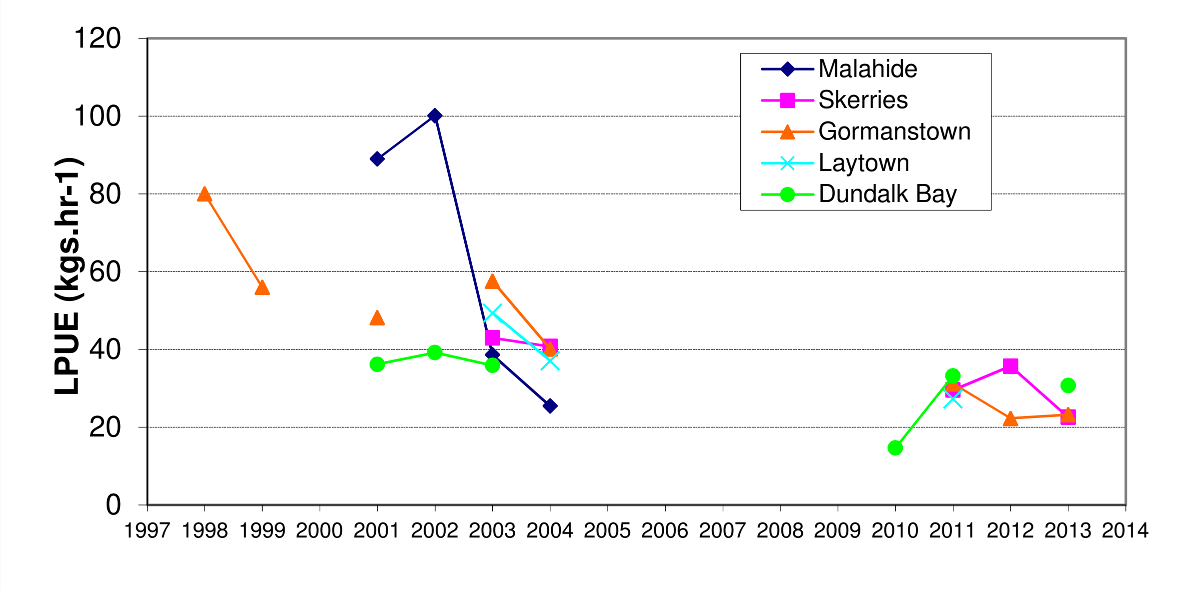

Figure 6. Annual average LPUE in the north Irish Sea razor clam fishery (1998-2013).

Table 8. Annual average (S.d.) LPUE (kgs.hr-1) of razor clams in 3 Razor clam beds in the north Irish sea 2010-2013 (source: SVP data).

Year	Dundalk Bay		Gormanstown		Skerries		N Irish sea (area unknown)	
	Mean	S.d.	Mean	S.d.	Mean	S.d.	Mean	S.d.
2010	14.70	13.95					39.10	15.94
2011	33.25	19.48	31.19	7.30	29.58	4.85		
2012			22.30	6.05	35.71	5.67		
2013	30.73	6.84	23.24	6.57	22.57	5.52		

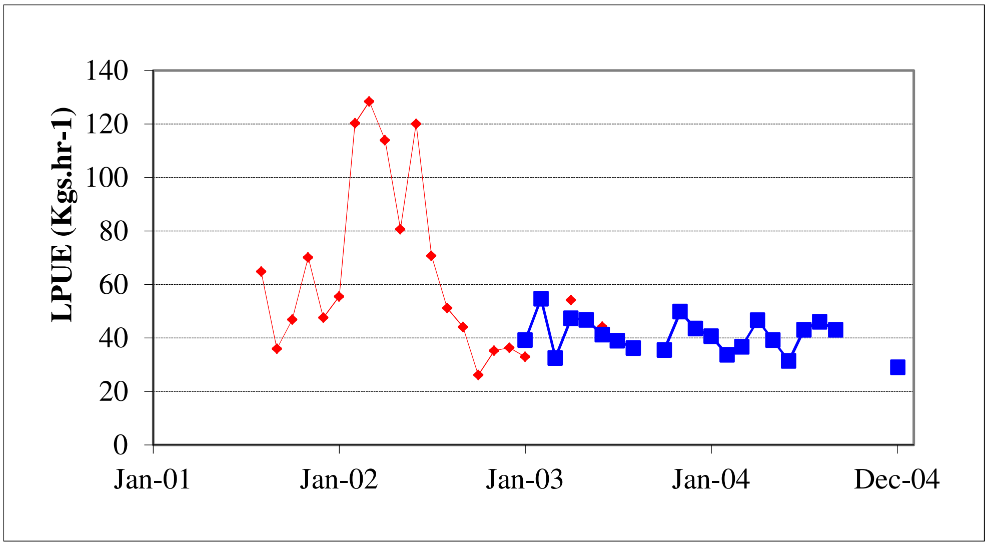

Figure 7. Monthly mean LPUE from the diaries of two fishing vessels fishing the north Irish Sea in 2002-2004.

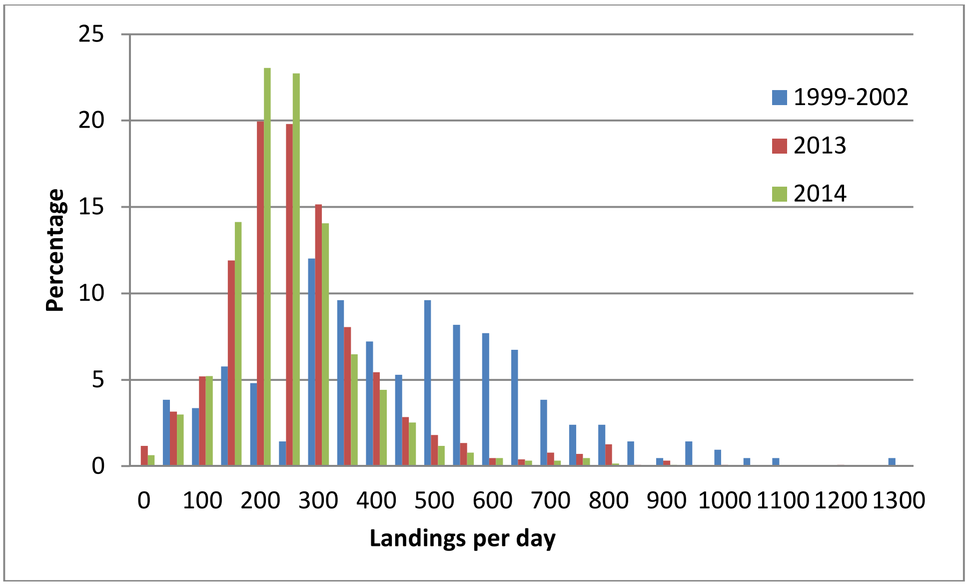

Figure 8. Distribution of daily landings (consignments) in gatherers data in the period 1999-2002 and 2013-2014. Source: SFPA Howth.

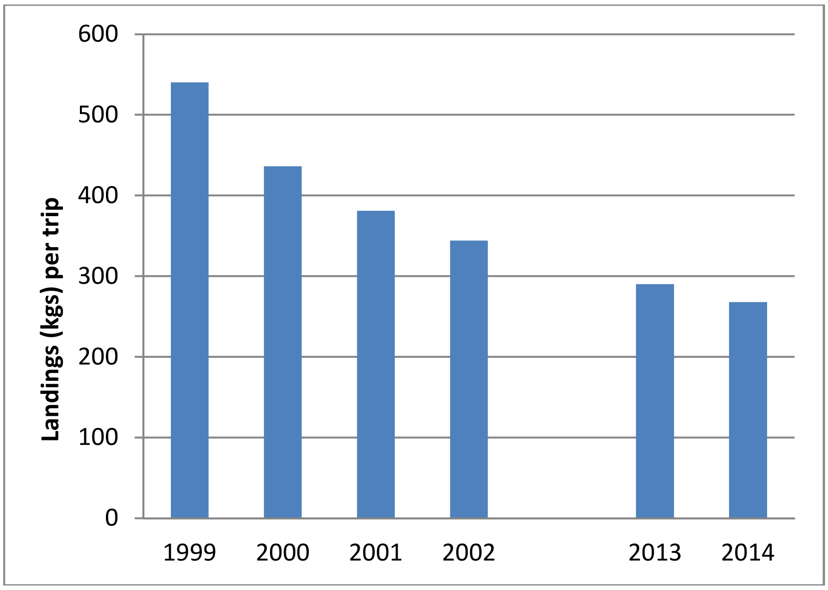

Figure 9. Annual mean landings per trip 1999-2002 and 2013-2014 (gatherers data, logbooks).

Table 9. Average consignment volume of razor clams in logbook data (>10 m).

Landing Year	Logbook daily volume kgs	
	Average	S.d.
2010	415.00	199.19
2011	380.10	180.33
2012	326.86	162.08
2013	296.03	149.83

5.6 Rosslare and Cahore

The fishery occurs mainly in and east of Rosslare Bay and further north at Cahore (Figure 10). The fishery developed in 2010 and is much more recent than the fishery in the north Irish Sea. Fishing activity in this area is concentrated east of Rosslare Bay and Wexford Harbour. Approximately 12 vessels fish in the area but this number changes seasonally. The fishery occurs close to or overlaps with a number of SACs and SPAs. The SAC designations to the east of the fishery are mainly sandbanks. Common Scoter, which feeds sub-tidally on bivalves, is designated in the nearby Raven SPA.

Daily landings volume in a sample of consignments in 2013 mostly ranged from 200-450 kgs (Figure 11). Average landings per trip in logbook data (vessels >10 m) from 2010-2013 increased during that time period (Table 10).

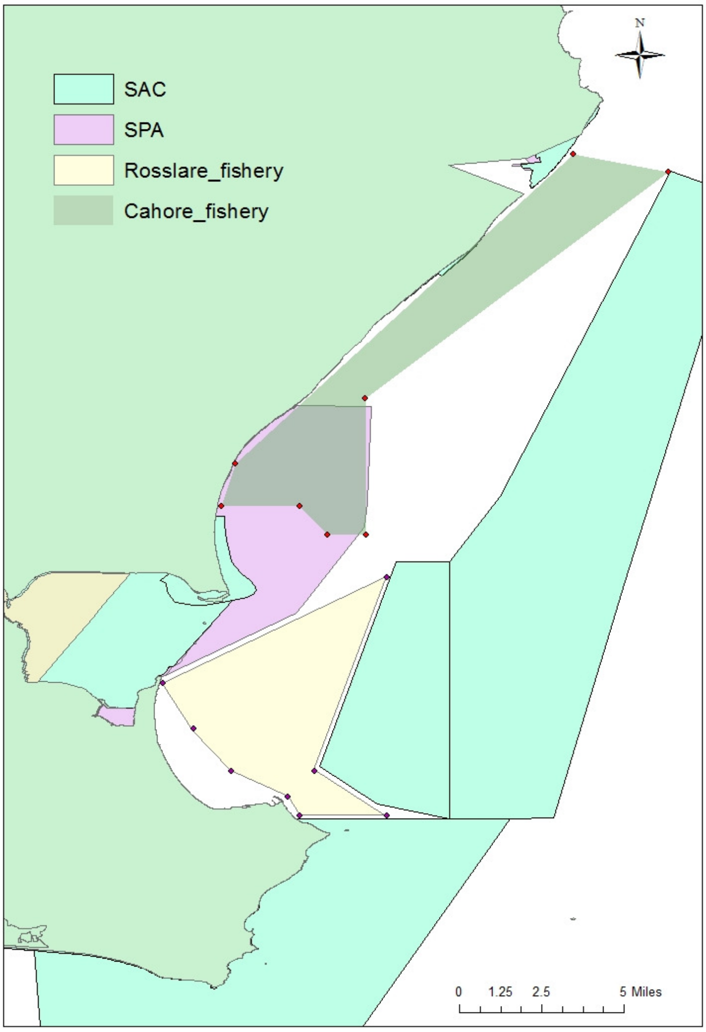

Figure 10. Fishable area (Fisheries Natura Declaration 3/2014) for Razor clams at Rosslare and Cahore in relation to the distribution of SACs and SPAs.

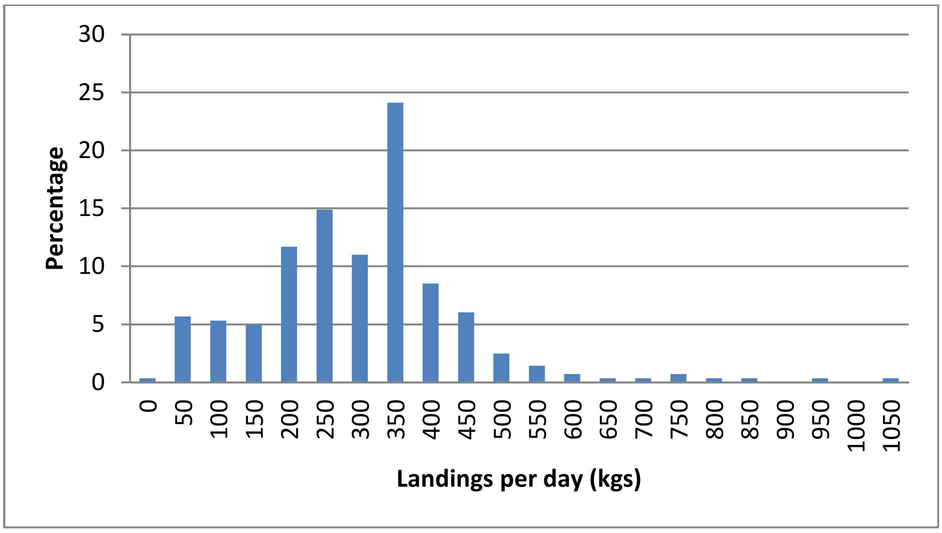

Figure 11. Distribution of landings per day in a sample of 282 consignments in the Rosslare fishery in 2013.

Table 10. Average consignment volume of razor clams in logbook data (>10 m) for Rosslare/Cahore fishery.

Landing Year	Logbook	
	Average	S.d.
2010	324.95	186.15
2011	492.93	370.94
2012	653.21	469.32
2013	907.14	1098.84

6 Mussels (*Mytilus edulis*)

6.1 Management advice

Castlemaine Harbour and the Irish Sea are under Natura 2000 site fisheries management regimes in relation to mussel fisheries.

Mussel cover in intertidal habitats of Castlemaine harbour, in 2012-2014, was regarded as not significant with respect to impacts on wading birds. The distribution and extent of intertidal seagrass beds in the area were stable during 2010-2014.

The mussel fishery in the Irish Sea continues to have a small spatial footprint and limited overlap with habitats in SACs. Whelk occurs in the by-catch and may be distributed to new areas during mussel relaying. Given the footprint of the mussel fishery it is unlikely to have any significant effect on whelk populations relative to the fishing mortality on whelk caused by the directed pot fishery.

Mussel size distribution data for the Irish Sea shows variation across mussel beds suggesting different age profiles.

In 2014 there was no correlation between the distributions of Common Scoter, a designated species of seabird in the Raven SPA in the south Irish Sea, and the subsequent location of the seed mussel fishery.

Monitoring of mussel cover in Castlemaine should continue. Additional data on the distribution of Common Scoter in relation to mussel fisheries in Castlemaine and in the south Irish Sea should be obtained.

Continued monitoring of mussel size distribution in space and time will indicate trends in recruitment and survival in areas exploited by the fishery.

6.2 Issues relevant to the assessment of the mussel fishery

Annual recruitment to mussel stocks (beds) in the Irish Sea and Castlemaine Harbour is variable. Recruitment and biomass is thought to have declined in the Irish Sea in recent years and is reflected in lower landings. 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. As many of the beds are dominated by seed mussel biomass changes rapidly due to growth and mortality and forecasting biomass that might be available to the fishery at any point in time is difficult. Age and biomass progression of mussel beds in different areas 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.

The Irish mussel fishery is certified by the Marine Stewardship Council (MSC) but with conditions. These conditions relate to the harvest strategy, by-catch and strategies, information and research for evaluating impacts of the fishery and relay of mussel on habitats and the ecosystem. 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. As such the fishery interactions with habitats and species in these areas are assessed and monitored. The main management issues relate to the harvest strategy for seed mussel beds, the ecosystem effects of that harvest and the habitat and species effects of the relay of mussel seed into aquaculture sites or fishery order areas.

6.3 *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 in the Irish Sea. From that perspective stocks in the Irish Sea can be viewed as separate to those on the south and west coasts. There may be local self recruiting stocks if larval retention within Bays is significant. Inner Dingle Bay and Castlemaine Harbour can be regarded as a separate assessment and management unit.

6.4 *Management measures*

Mussel quotas are allocated to authorised fishing vessels following stock surveys by BIM in the Irish Sea and Castlemaine Harbour. All vessels report GPS position during fishing. In Castlemaine exploitation is limited to 66% of the biomass estimated by survey in order to conserve prey resource for Common Scoter in inner Dingle Bay. There is no limit to the exploitation rate in the Irish Sea. An area of sensitive habitat in Wicklow Head SAC is closed to fishing for mussels. The fishery has a limited season.

6.5 *Castlemaine Harbour*

Castlemaine Harbour is designated as a Special Area of Conservation (SAC) and a Special Protection Area (SPA) for birds. The seed fished from inner Dingle Bay is re-laid in the intertidal area of Castlemaine Harbour prior to subsequent on-growing in sub-tidal areas of the Harbour. The relay can have a number of effects; the habitat in the area where the mussel is relayed can change as a result of mussel cover, the relative suitability of the intertidal habitat for wading birds can be reduced for some species and possibly enhanced for others thereby potentially leading to changes in the bird community using the habitat. Mussels may encroach onto the seagrass bed which occurs to the west of the relay area. The % of the intertidal habitat that is covered with relayed mussel is used as an indicator of habitat quality and suitability of the area for wading birds.

6.5.1 Mussel biomass and relays 2011-2014

Annual biomass in areas surveyed by BIM in inner Dingle Bay varied from 2,900-3,500 tonnes in 2011-2014. Although significant spawning occurred in 2013 seed beds did not develop and biomass of exploitable seed was assessed to be 0. Biomass fished and relayed in Castlemaine Harbour was 640 tonnes in 2011, 1,542 tonnes in 2012, 0 tonnes in 2013 and 2,299 tonnes (provisional) in 2014 (Table 11).

Table 11. Stock estimates, landings and results of mussel cover and seagrass monitoring in Castlemaine Harbour 2011-2014.

	2011	2012	2013	2014
Biomass and fishery				
Stock biomass	3000	3000	0*	3500
Biomass fished	640	1542	0	2299**
Vessels licenced	7	6	0	
Intertidal monitoring:				
mussel cover		May	Feb	June
seagrass		Aug	Aug	Sept (EPA)
% cover		5-16%	5-11%	<8%
seagrass extent		Stable	Stable	Stable

6.5.2 Monitoring of intertidal habitats

6.5.2.1 Methods

The intertidal area is surveyed using a remotely operated Unmanned Aerial Vehicle (UAV) (http://www.sensefly.com/products/). Flight planning and communication with the UAV is managed using E-mot-ion® software on a standard laptop PC. Flight altitude is approximately 100-110 m resulting in an image resolution of 3.4-4.4 cm.pixel^{-1}. Individual images overlap geographically by 45-60% to ensure smooth meshing and mosaic production. The image mosaic of the fly over areas is produced using custom software from Sensefly post flight services following image geo tagging using flight log information recorded for each image during the flight. Mussel cover in the area surveyed by the UAV is estimated from the image mosaic using the unsupervised classification procedure in the image analysis tool in Spatial Analyst in ArcGIS 10.2.

The extent of the seagrass bed and in particular the location of its eastern border, which is closest to the mussel relay activity, is monitored by the Environmental Protection Area (EPA) and MI. MI survey the eastern boundary by walking and recording GPS position of the boundary every 5 m.

6.5.2.2 Results

In May 2012 mussel cover in the intertidal relay area was 16.1% and 5.8% in the southern and northern sections, respectively. Mussel cover in the area between the seagrass bed and the intertidal relay area was 9.7% and 11.3% in the southern and northern survey images, respectively.

In February 2013 analysis of the UAV images indicates that 8% of the total area, which was surveyed was covered in mussel. Mussel cover in the north section of the survey area was 5.72% and 10.87% in the southern section. In June 2014 the north part of the surveyed area has almost no mussel cover while the cover in the south of the area was similar to 2013. (Figure 12, Figure 13, Figure 14, Figure 15).

The northern part of the area, which had lower mussel cover in 2012 and 2013, is the area which receives most if not all of the seed relay. However, the volumes re-laid were low in 2012 and zero in 2013. The southern part of the relay area which has higher % mussel cover, is not actively managed by operators to the same extent as the northern area and has mature mussel beds which are also partly covered in Fucoid seaweeds.

The % mussel cover recorded is, based on bird research work commissioned by the Marine Institute in 2011, not deemed to be significant with respect to habitat quality for birds.

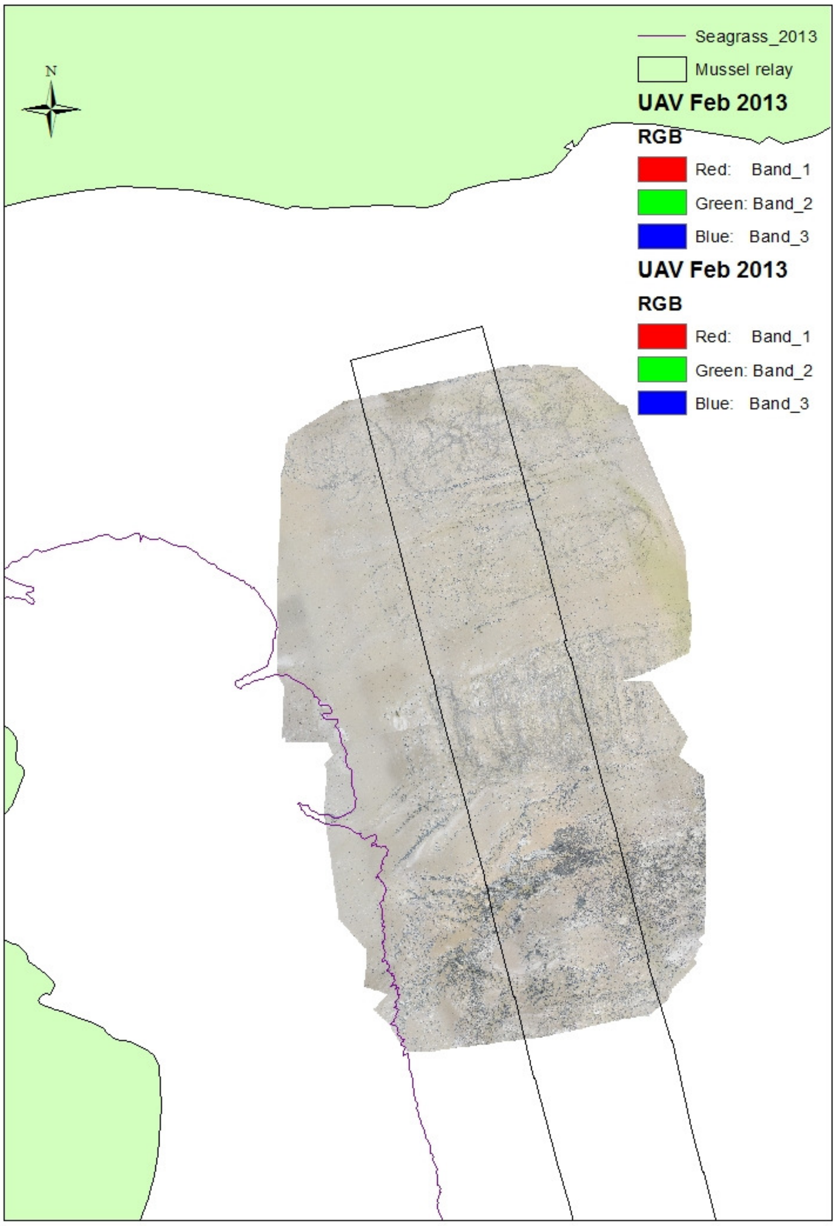

Figure 12. Aerial imagery of mussel cover in the intertidal habitat in Castlemaine Harbour in February 2013 and the distribution of seagrass in August 2013. Mussel cover is higher in the south of the relay area.

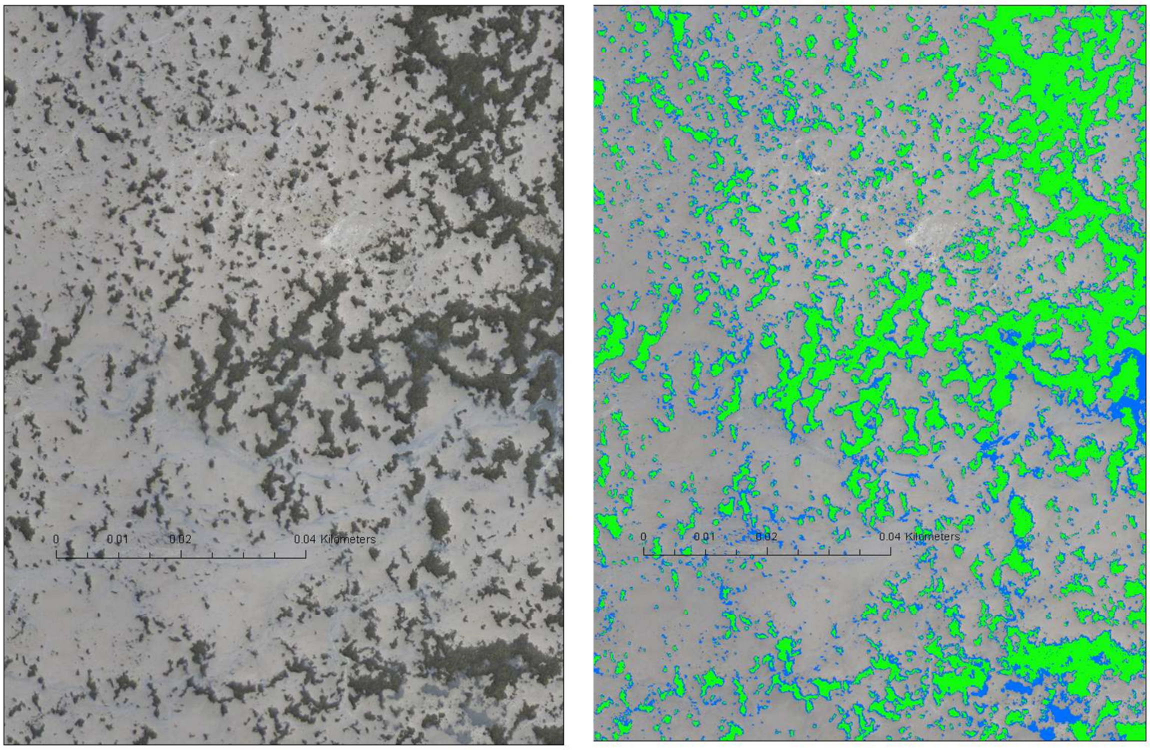

Figure 13. Close up (note scale bar, 40 m) from aerial image (left) and classified aerial image (right) of mature mussel cover in an intertidal area of Castlemaine Harbour. Dark (green in classified image) areas are mussel and grey (blue in classified image) is mussel mud surrounding mussel patches. Background is sand.

Figure 14. Left: Close up from aerial image of relayed mussel in February 2013 showing presumed pattern of vessel movement during relay. Right: eastern edge of seagrass bed in June 2014.

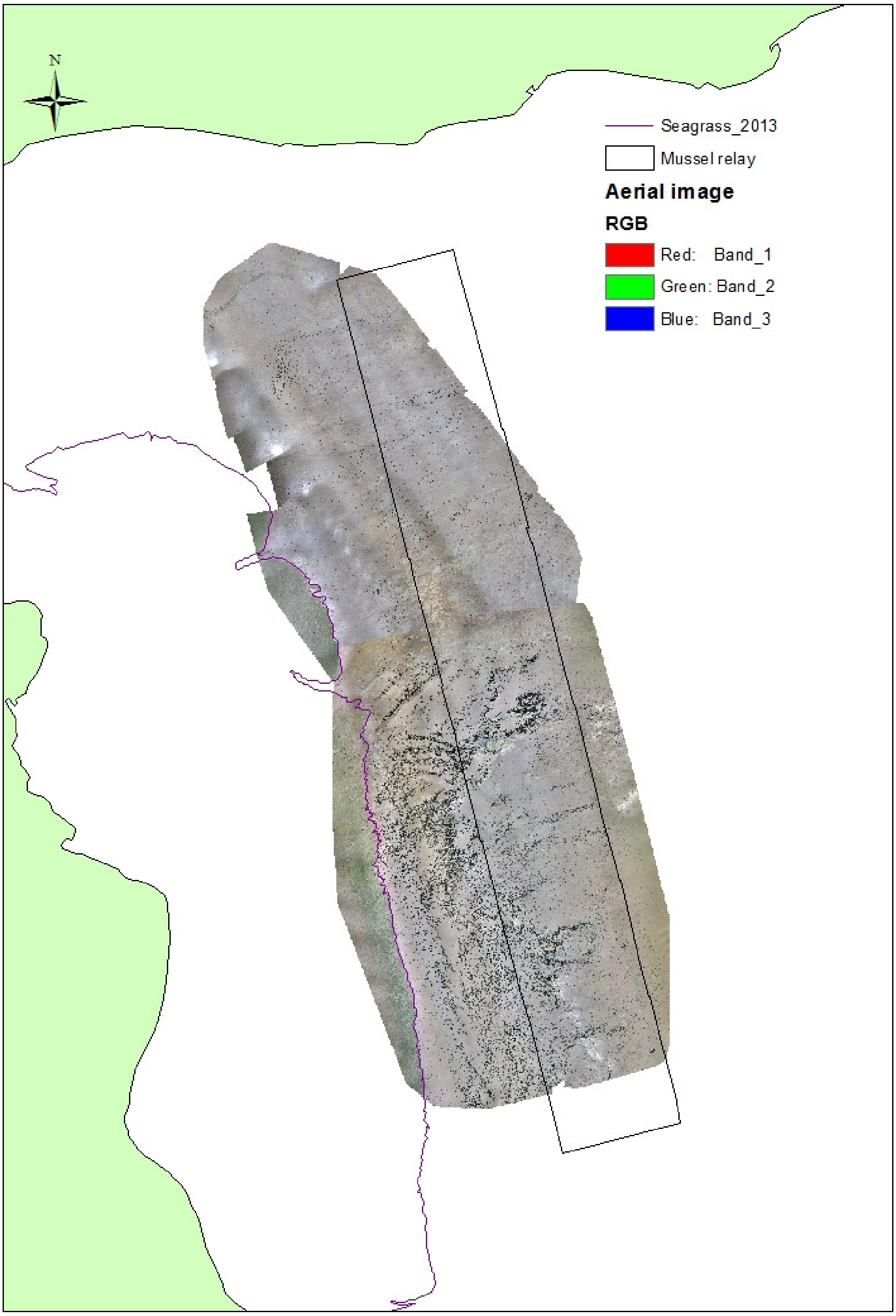

Figure 15. Aerial imagery of mussel cover in the intertidal habitat in Castlemaine Harbour in June 2014, the eastern boundary of the seagrass bed obtained from GPS ground survey is shown and corresponds to the edge in the aerial image. Mussel cover is higher in the south and west of the relay area between the relay area and the edge of the seagrass bed.

6.6 *Irish Sea*

6.6.1 Location of sampling in 2014

Samples of by-catch and size distribution of mussels were taken on board commercial seed mussel vessels fishing at Rusk Channel (western edge of Blackwater Bank SAC) and west of Long Bank (Figure 16).

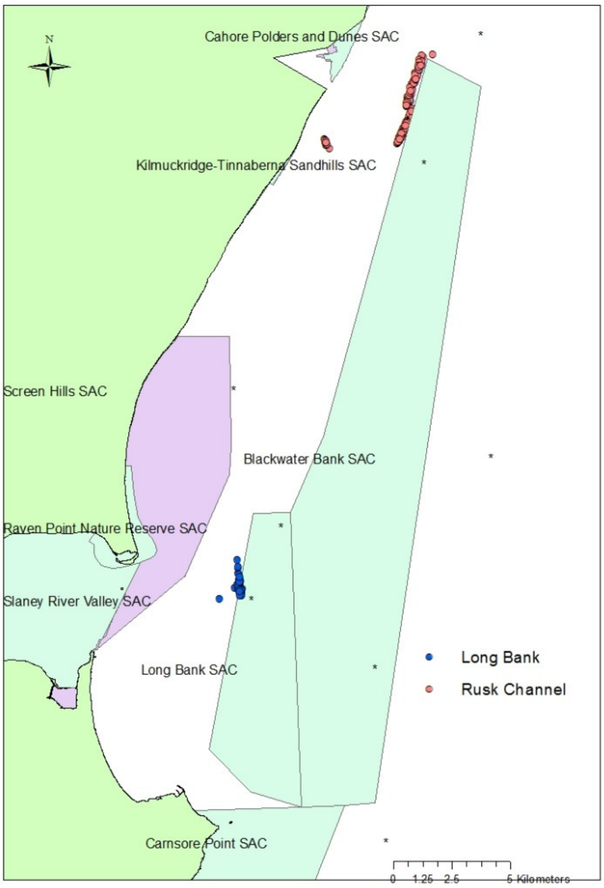

Figure 16. Location of seed mussel fishing during sampling in 2014 at Long Bank and Rusk Channel. SACs and SPAs are shown.

6.6.2 Size distribution of mussel in the catch

Mussel size distribution varied spatially across different fishing areas (mussel beds). Within the beds size varied from 4-33 mm in the Rusk Channel and 5-39 mm at Long Bank. The age distribution is unknown but if growth rate is equivalent in each of the areas it suggests that mussels at Long Bank were older than at Rusk Channel during the fishery (Figure 17).

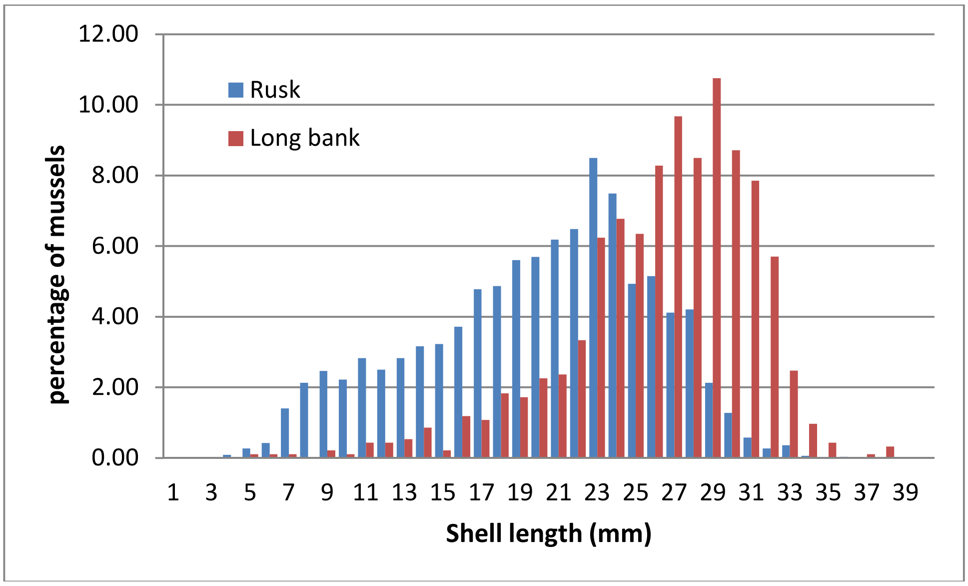

Figure 17. Size distribution of mussels in the catch at Rusk Channel and Long Bank fishing areas in the Irish Sea in August-September 2014.

6.6.3 By-catch in the seed mussel fishery

By-catch was estimated from 2 kg samples of the catch randomly drawn from the contents of the mussel dredge over a period of 6 days from August 17th to September 8th 2014. Starfish, unidentified crab, green crab, spider crab, whelk and scallop were the main by-catch species. By-catch was more diverse in Rusk Channel samples compared to Long Bank samples.

None of the by-catch represent main retained species for MSC certification as they are all less than 5% of the volume of the mussel catch and none of the by-catch species are subject to recovery plans.

The by-catch of whelk averaged 1,000 individuals per tonne of catch in Rusk Channel. Dispersal of whelk, which does not have a pelagic larval phase, into relay areas may contribute to establishing new populations of this species in these areas.

Table 12. Species caught as by-catch in the Irish Sea seed mussel fishery at Rusk Channel and West long bank in 2014. Average numbers in 2kg sample of catch.

Species	Rusk Channel		West Long Bank	
	Average	S.d.	Average	S.d.
Brown crab			1.00	
Crab spp	2.54	1.51		
Green crab	2.17	1.58	2.38	2.39
Round fish	1.50	1.00		
Scallop	1.00	0.00	1.00	
Spider crab	1.33	0.58	1.33	1.03
Starfish	4.55	3.79	7.38	3.16
Whelk	2.07	1.44	1.00	

6.6.4 The distribution of Common Scoter and mussel fishing

Mussels and other bivalves are prey for Common Scoter in the south Irish Sea. This species dives for bivalve prey in waters less than 20 m deep and where currents are <0.6m.s^{-1}. An aerial seabird survey was completed in March 2014 to estimate the distribution of Common Scoter and other seabirds in the south Irish Sea in relation to the distribution of fisheries for mussels and razor clams.

In March 2014 there was no particular spatial association between the occurrence of Common Scoter and the location of fishing for seed mussels the following August (Figure 18). Scoter occurred throughout the survey area. This survey was towards the end of the overwintering period for Common Scoter and numbers recorded in the survey were low. A second survey was completed in December 2014 and results are pending.

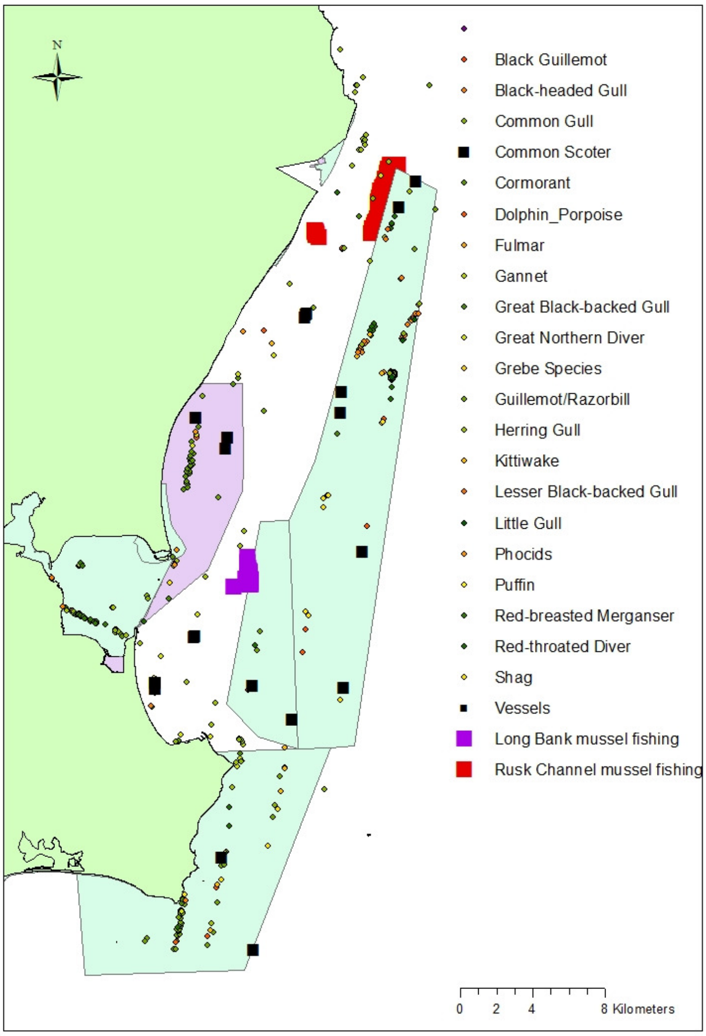

Figure 18. Distribution of seabirds including Common Scoter and sea mammals (Phocids (seals), Dolphin_Porpoise) in the south Irish Sea in March 2014 in relation to the location of seed mussel beds fished in August-September 2014. SACs and SPAs are shown. Each dot represents the location of an individual bird. Clusters of birds are those recorded on flight transects which covered approximately 12% of the ground area at 2.5 km spacing. Data have not been interpolated because of the low numbers recorded.

7 Cockle (*Cerastoderma edule*)

7.1 Management advice

Dundalk Bay is under a Natura 2000 site fisheries management regime.

The Dundalk cockle stock is assessed by annual survey and in season LPUE data. TAC is 33% of total biomass on condition that ecosystem indicators for designated habitats and bird populations are stable.

The management regime for cockles in Dundalk Bay in the period 2007-2014 used a suite of measures which effectively limited exploitation rates and protected juvenile cockles.

Maintenance of good environmental status in the intertidal habitats in which these fisheries occur should be a primary objective in order to reduce the risk of future recruitment failure and to ensure that conservation objectives for designated habitats and species are protected.

Cockle fisheries in SACs or SPAs in other areas should be subject to management plans considering their potential effects on designated habitats and birds.

7.2 Issues relevant to the assessment of the cockle fishery

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

Recruitment of cockles in Dundalk Bay occurs regularly but overwinter survival, in particular, is highly variable. As a consequence biomass, in some years, is insufficient to support a fishery. Recruitment failures occur frequently in the Waterford estuary and overwinter survival is also generally low.

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.

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

Continuing commercial fisheries for cockles in Natura 2000 sites will depend on favourable conservation status of designated environmental features that may be affected by this fishing activity.

7.3 Management Units

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

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

7.4 Management measures

The management measures and annual operation of the fishery are described in a 5 year management plan (2011-2016) and specified in annual legislation in the form of a Natura Declaration (www.fishingnet.ie).

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

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

Environmental performance indicators are reviewed annually as part of the 2011-2016 management plan and the prospect of an annual fishery depends on annual evidence that there is no causal link between cockle fishing and in particular the abundance of oyster catcher and the status of characterising bivalve species and the polychaete:bivalve ratio of intertidal habitats.

7.5 Dundalk Bay

7.5.1 Biomass 2007- 2014

Biomass estimates from annual surveys in 2007-2014 are not strictly comparable because of differences in the time of year in which surveys were undertaken (Table 13). The annual estimates are highly sensitive to the timing of in year settlement and seasonal mortality of established cohorts relative to the time in which the surveys are undertaken. The March 2007 survey for instance would not have detected settlement that occurred in 2007. Nevertheless since 2009 surveys have been undertaken either in May or June.

The 2007 biomass of 2,277 tonnes consisted mostly of cockles greater than 18 mm shell width. The fishery in 2007 removed approximately 900 tonnes (including an approximate estimate for hand gatherers) of cockles over 22 mm. Biomass was highest in 2008 due to a strong recruitment in the spring of 2008. The majority of the biomass in 2008 was less than 18 mm shell width and dominated by the 0+ cohort. There was no fishery in 2008. Biomass in 2009 was lower than in 2008 and similar to 2007. This was mainly due to lower densities of 0+ cockles. The biomass in 2010 was approximately 25% of the 2009 biomass and by far the lowest recorded since 2007. The stock in 2010 was dominated, numerically, by recently settled 0+ cockles and a low population density of adult cockles. The 1+ and 2+ cohorts were weakly represented. In May 2011 the biomass was 1,531 tonnes. The population was dominated numerically by 0+ and 1+ cohorts. In 2012 biomass was 1,234 tonnes. The size distribution of cockles was dominated by the 0+ and 1+ cohorts at modal shell widths of approximately 8 mm and 21 mm. In 2013 0+, 1+ and 2+ cohort were strongly represented. Biomass was 1,260 tonnes. In 2014 cockles aged 2+ and older were not abundant. The 0+ cohort was common but not as abundant as in 2012-2013. A 0+A cohort, spawned in Autumn 2013 was present. Biomass was 972 tonnes.

Although the stock was not fished in 2008 the biomass was lower in 2009 and lower again in 2010 despite the total landings from the 2009 fishery being only 108 tonnes. Natural mortality appears to have been very high during the winters of 2008-2009 and 2009-2010. This was verified by sampling of a high density patch of cockles from August 2008 to March of 2009 in the middle of the south Bull area. The biomass estimated in 2011 was approximately twice that recorded in 2010. Biomass was stable at 1,200-1,500 tonnes in 2011-2013 and resulted in 3 successive fisheries in autumn of those years. Landings were lower than the TAC in each of these years but especially in 2011. Biomass was lower in 2014. Although the biomass in 2014 was higher than the limit biomass reference point for the fishery to open no fishery occurred.

Table 13. Annual biomass, TAC and landings of cockles in Dundalk Bay 2007-2013.

Year	Survey Month	Biomass		TAC (tonnes)	Landings	
		Mean	95% CL		Vessels	Hand gatherers
2007	March	2277	172	950	668	Unknown
2008	August	3588	1905	0	0	0
2009	June	2158	721	719	108	0.28
2010	May	814	314	0	0	0
2011	May	1531	94	510	325	0.25
2012	May	1234	87	400	394	9.40
2013	June	1260	99	416	343	0
2014	June	972	188	0	0	0

7.5.2 Biomass in 2013 and 2014

Pre fishery surveys were completed in June 2013 and 2014.

In 2013 the total biomass, ± 95% confidence limits, of cockles in the sampling domain (26.97 km^2) was 1,260±99 tonnes (Table 14, Figure 19). Approximately 624 tonnes of this biomass occurred in densities of over 5 m^{-2}, which was 60% down on 2012. The biomass of cockles over 18 mm shell width was 1,066±78 tonnes with approximately 122 tonnes occurring in densities over 5 m^{-2}. The biomass of cockles greater than 22 mm shell width was 692±21 tonnes. All of which occurred in densities over 5 m^{-2}.

In 2014 the total biomass, ± 95% confidence limits, of cockles in the sampling domain (27.2 km^2) was 972±188 tonnes (Table 15, Figure 20). Densites were less than 5 cockles.m^{-2} in 46% of the area and less than 10 cockles.m^{-2} in 88% of the area.

Table 14. Distribution of cockle biomass in Dundalk Bay in June 2013.

Contours	Area		Density				Biomass (gm^{-2})		Biomass (tonnes)	
	Area (m^2)	% of area	N	Mean	S.d.	CL	Mean	CL	Mean	CL
0	153782	0.57	56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.12 - 0.99	2038852	7.56	54	0.48	0.21	0.06	7.32	1.28	14.93	2.60
1.0 - 4.99	17385640	64.46	163	2.82	1.15	0.18	35.76	2.84	621.63	49.35
5.0 - 9.99	6866247	25.46	79	6.84	1.41	0.31	81.24	5.69	557.79	39.07
10.0 - 24.99	525954	1.95	23	13.11	3.30	1.35	126.41	16.78	66.49	8.83
Total	**26.97km²**		**375**						**1260**	**99**

Table 15. Distribution of cockle biomass in Dundalk Bay in June 2014.

Contour	Area		Density				Biomass ($g.m^2$)		Biomass (tonnes)	
	Area (m^2)	% of area	N	Mean	S.d.	95%C.L.	Mean	95% C.L.	Mean	95% C.L.
0	565	0.00	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0-0.99	2559937	0.09	97	0.1959	0.258	0.05	1.17	0.50	3.00	1.29
1-4.99	12234894	0.45	116	2.9418	1.428	0.26	27.41	4.46	335.32	54.61
5-9.99	9234544	0.34	74	7.1318	1.394	0.32	40.89	6.00	377.58	55.38
10-150	3194268	0.12	59	17.568	19.37	4.94	80.17	24.31	256.10	77.66
Total	**27.22km²**		**351**						**972**	**188**

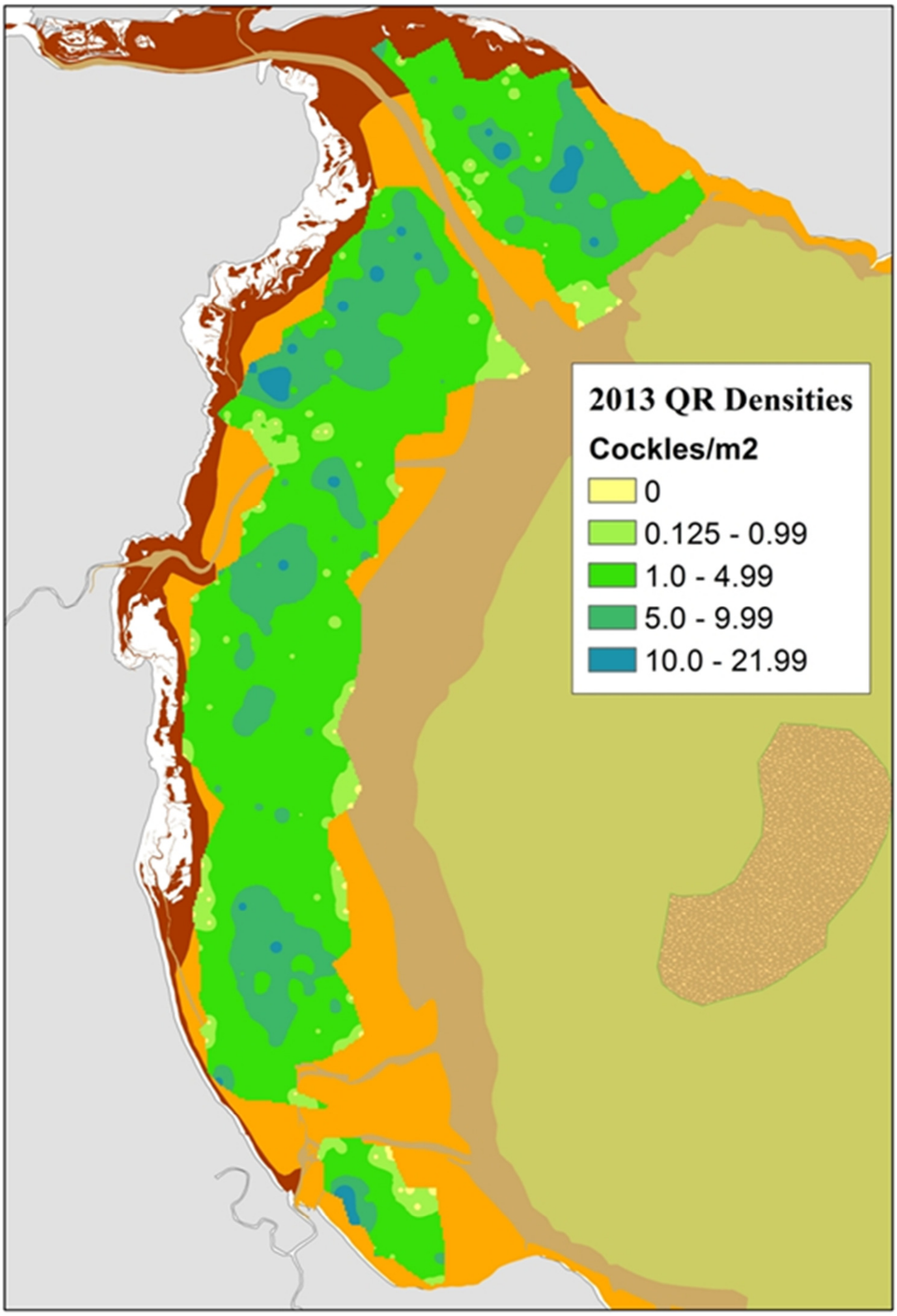

Figure 19. Distribution of cockles in Dundalk Bay in June 2013. The surveyed area was 26.97 km^2. QR is the combined densities in rake and quadrat samples.

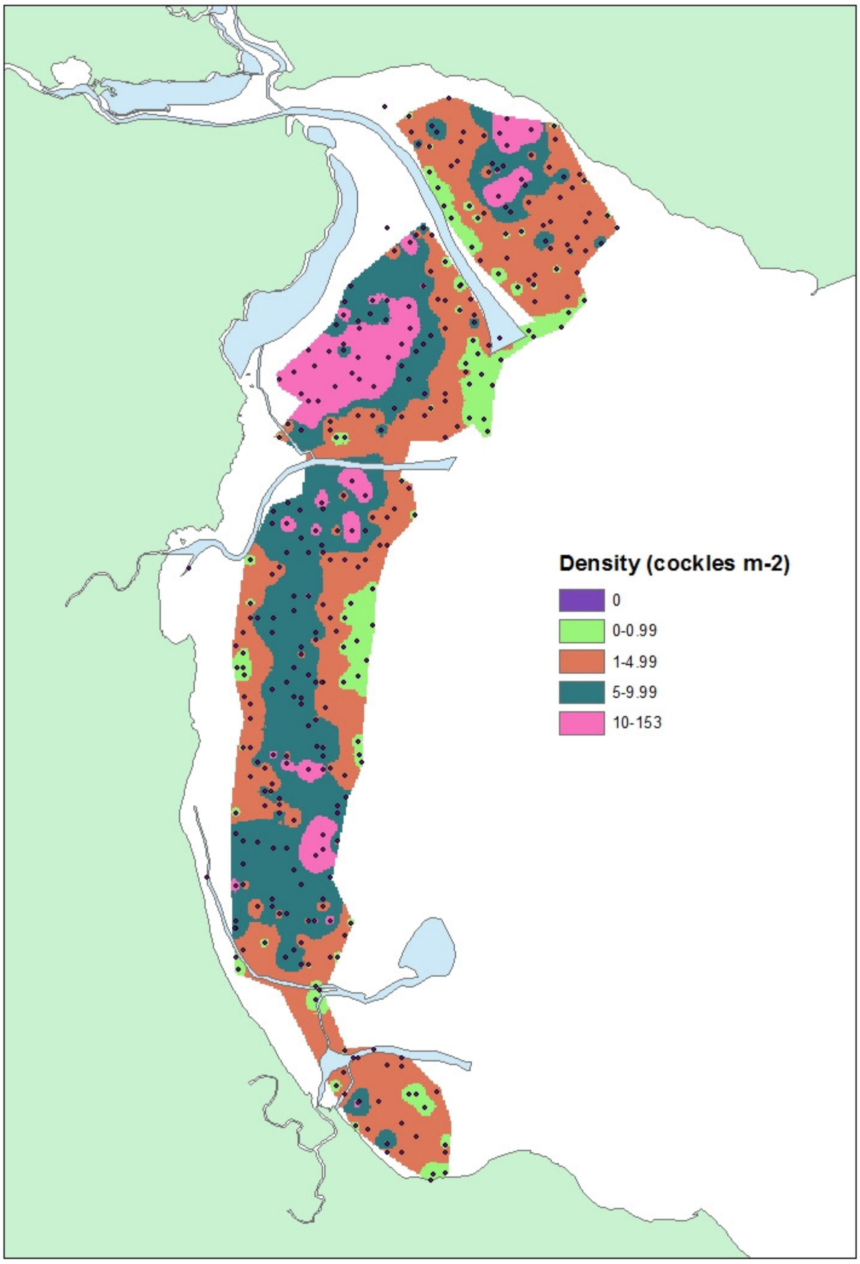

Figure 20. Distribution of cockles in Dundalk Bay in June 2014. The surveyed area was 27.2 km^2. Sampling points are shown.

7.5.3 Size and age in 2013 and 2014

In 2013 the size distribution was bi-modal representing 0+ cockles which settled in spring of 2013, 1+ cockles (13%) and 2+ cockles (18%). Older cohorts were less abundant in 2014 and the population was mainly of 0+, 0+A (2013 autumn spawned) and 1+ cockles (Figure 21).

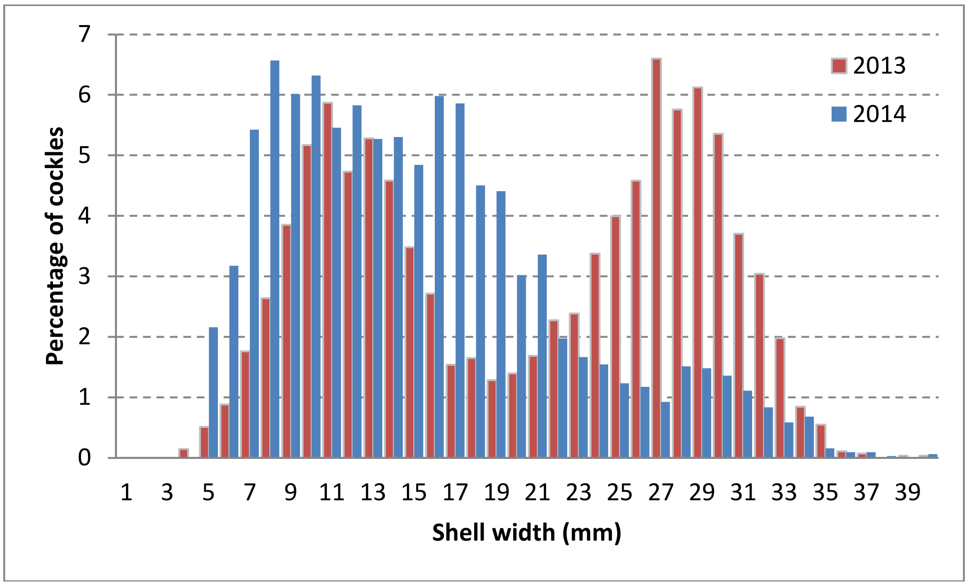

Figure 21. Shell width distribution of cockles in Dundalk Bay in June 2013 and 2014. The operational minimum landing size is 22 mm.

7.5.4 Landings and catch rates in 2013

Landings in 2013 were 343 tonnes from a TAC of 416 tonnes.

Catch rates (excluding the first 2 weeks which are usually atypical as vessels make adjustments to fishing gear) declined from 127 kgs.hr^{-1} in week 33 to 85 kgs.hr^{-1} in week 36. Catch rates were stable from week 36 to the close of the fishery in week 39 (Figure 22). The average catch per day varied from 630 kgs in week 2 to 334 in week 8 (suggesting a 46% exploitation rate of cockles over 22 mm shell width). The catch rate at the end of the fishery was 84 kgs above the limit reference point of 250 kg which, according to the management plan, would result in closure of the fishery (Table 16).

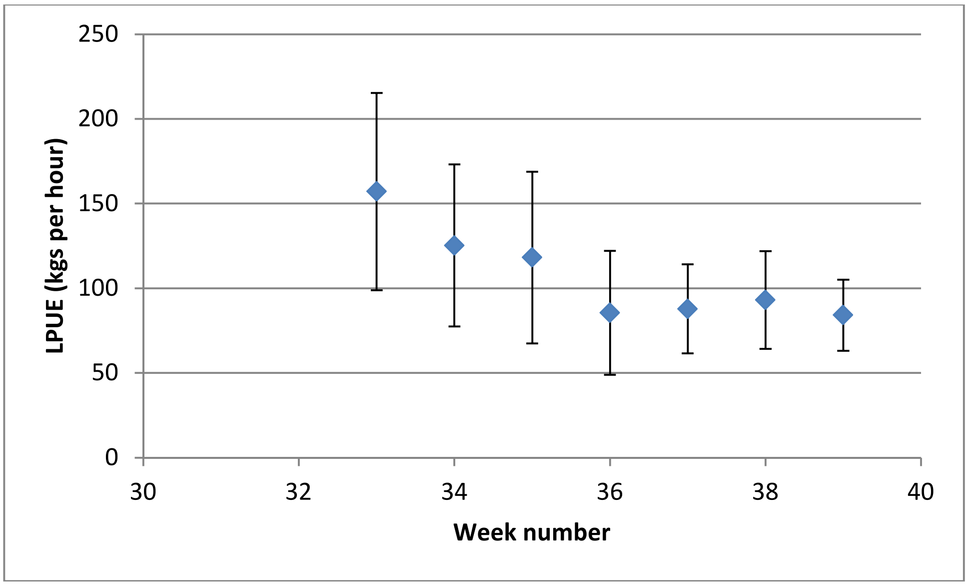

Figure 22. Average landing rate per hour (kgs.hr^{-1}) in each week of the fishery in 2013.

Table 16. Average daily catch, number of trips and tonnes landed per week during the 2013 cockle season (4th August – 26th September). Source: SFPA, Howth.

Week No.	Dates	Average Daily catch per week (kg)	No. Trips	Tonnes/week
1	04-10.08.13	613	120	73.521
2	11-17.08.13	630	79	49.804
3	18-24.08.13	513	165	84.622
4	25-31.08.13	419	72	30.167
5	01-07.09.13	370	49	18.118
6	08-14.09.13	382	99	37.816
7	15-21.09.13	343	97	33.268
8	22-28.09.13	**334**	49	16.36
Totals			**730**	**343**

7.6 Ecosystem indicators

7.6.1 Distribution and abundance of non-target invertebrate species

The spatial distribution of *Angulus tenuis* and *Macoma balthica* in 2013 and 2014 was similar to that in 2012 and 2011. *Angulus* was more abundant on the mid and lower shores and *Macoma* was more abundant on the upper shore (Figure 23, Figure 24). The mean abundance (and variability) of *Angulus* was higher in 2013 and 2014 compared to 2011 and 2012 (Table 17); for instance the number of samples in which densities exceeded 100 m^{-2} was higher in 2013 and 2014 indicating patches of habitat with higher densities of *Angulus* in those years compared to 2011-2012. Both species are short lived and their populations are significantly affected by environmental conditions and predation. These annual variations, as is the case with cockle, probably result from varying overwintering survival and larval settlement during spring.

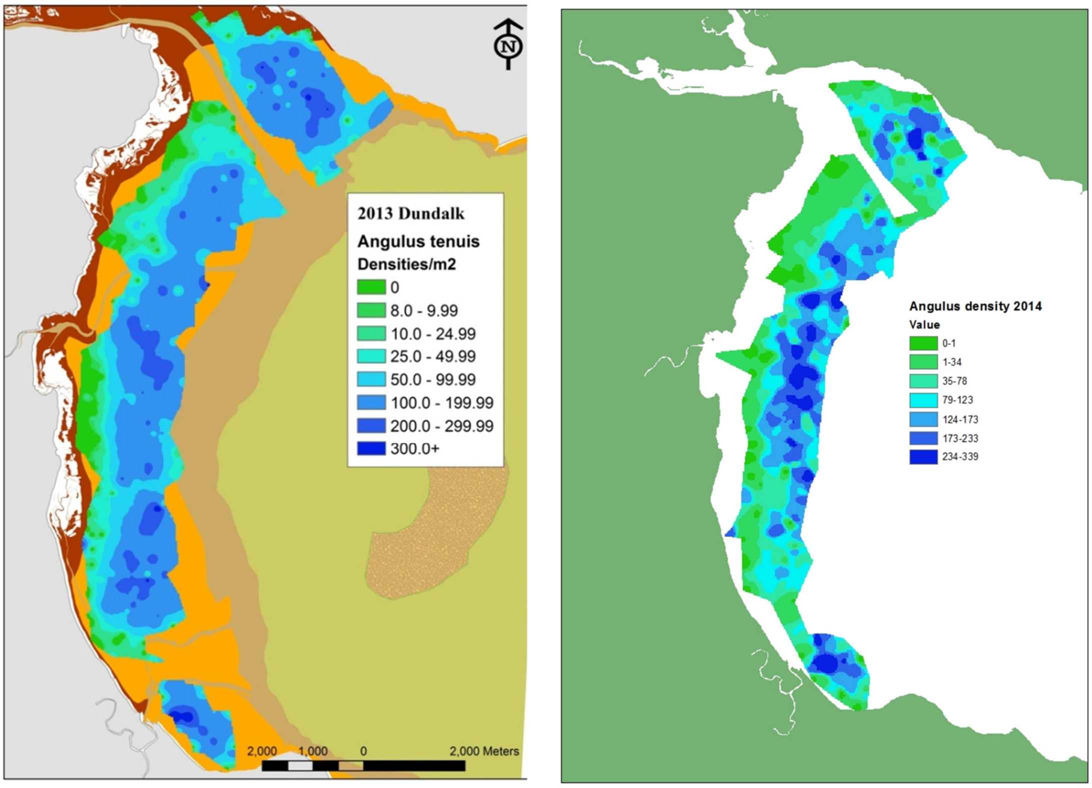

Figure 23. Density distributions of the bivalve *Angulus tenuis* in Dundalk Bay in 2013 and 2014.

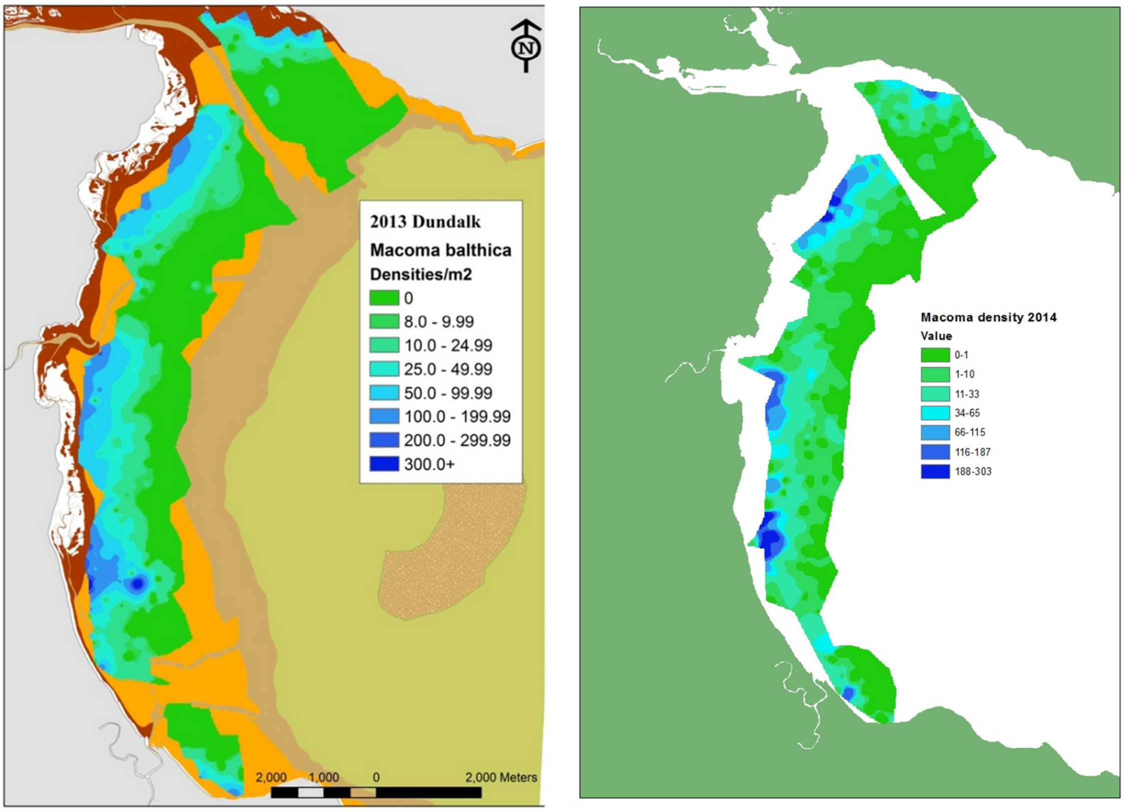

Figure 24. Density distributions of the bivalve *Macoma balthica* in Dundalk Bay in 2013 and 2014.

Table 17. Annual mean density (number.m^{-2}) of *Angulus tenuis* and *Macoma balthica* in quadrat samples taken in cockle surveys in Dundalk in 2011-2014.

Year	*Angulus tenuis*		*Macoma balthica*	
	Average	S.d.	Average	S.d.
2011	26.14	38.74	13.98	36.25
2012	55.35	62.18	17.74	41.21
2013	95.43	89.82	28.10	57.49
2014	91.61	83.19	18.53	42.23

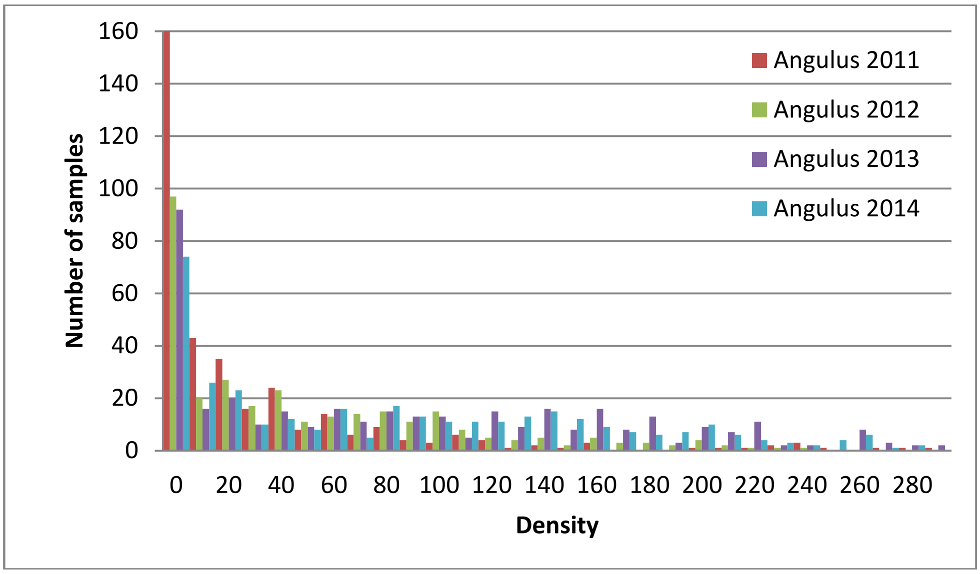

Figure 25. Density distribution of *Angulus tenuis* in annual surveys 2011-2014.

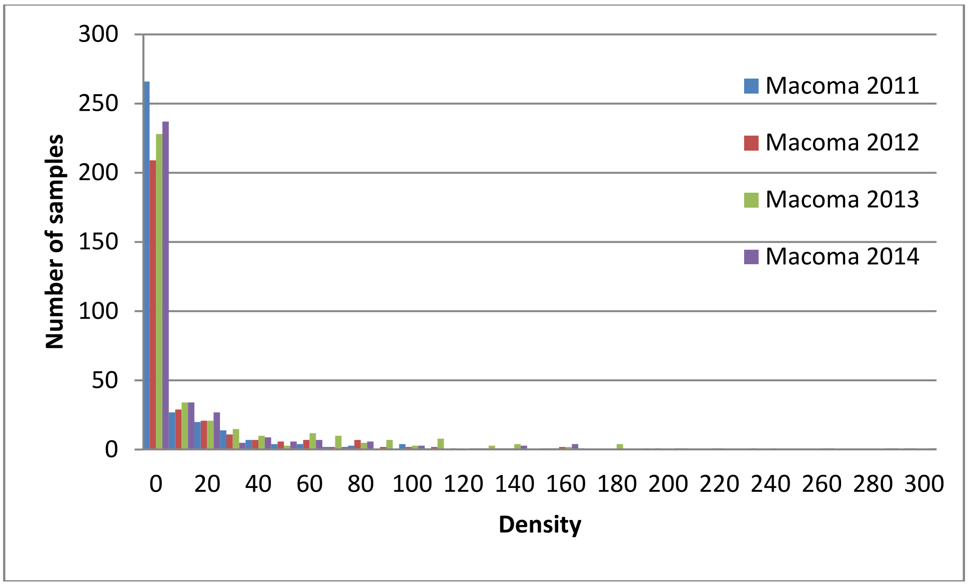

Figure 26. Density distribution of *Macoma balthica* in annual surveys 2011-2014.

7.6.2 Oystercatcher population trends

In the period 2011-2014 two independent surveys of oystercatcher populations have been completed; a high tide monthly count by I-WeBS and a low tide monthly count by the Atkins under contract to the MI. Comparison of these data sets shows that the I-WeBS survey can significantly underestimate the number of oystercatcher at the site.

Low tide count data from Atkins are considered to provide an accurate and precise population estimate; for instance successive monthly counts in autumn have shown very similar total number of birds indicating that the count method has repeatability. These data indicate a maximum total population size for 2012/13 of around 10,500 birds (Figure 27). This peak occurred in December-January. The maximum number was just over 11000 in 2013/14 and occurred in October-November of 2013. Numbers declined rapidly in December 2013-January 2014. Peak numbers of birds remained much lower throughout the autumn of 2014 than in the previous 2 seasons. The main reduction in numbers occurred in the main sandflats although numbers in the upper shore and outer bay (north and south margins) were also lower. Varying numbers of oystercatcher feed in fields in the countryside surrounding the Bay. Precise estimation of the number feeding in fields is difficult and such counts are usually incomplete. Numbers exceed 1,000 birds on some count dates.

The cockle fishery in 2013 closed at the end of September. Catch rate data suggested a 46% exploitation rate on cockles >22 mm shell width by that time. Numbers of oystercatcher on the main sandflats continued to increase until at least mid-November 2013.

The decline in numbers subsequently in December 2013 and January 2014 occurred more rapidly than in previous seasons. It is not known (at time of writing) if this decline also occurred at other sites on the east coast. Numbers of oystercatcher did not re-build to levels seen in 2012 and 2013 during autumn 2014. There was no cockle fishery in 2014 as biomass of cockles was lower than in 2012 and 2013. Densities of *Angulus* were higher in 2013 and 2014 than in previous years. The habitat quality for oystercatcher in 2014 was therefore less favourable than in 2012 or 2013 due to lower cockle biomass although this difference was only about 300 tonnes of cockles. *Angulus* is also taken by Oystercatcher however and was more abundant in 2013 and 2014.

Taking the period 2007-2013 iWeBs oystercatcher peak count data for autumn-winter is positively related to the post fishery biomass of cockles in early autumn in the same year suggesting that the oystercatcher population is responding to annual changes in the biomass of cockles at the site. As the iWeBs data may underestimate the number of oystercatcher in the Bay by approximately 30% evidence for this relationship assumes that the underestimation is consistent across years. Evidence from the 3 years of low tide count data is less clear; in the 3 years for which low tide count data are available the number of birds varied from just over 6,000 to 11,300 at post fishery cockle biomass of approximately 1,000 tonnes. In this case the oystercatcher population is very significantly different at a given cockle biomass (Figure 28).

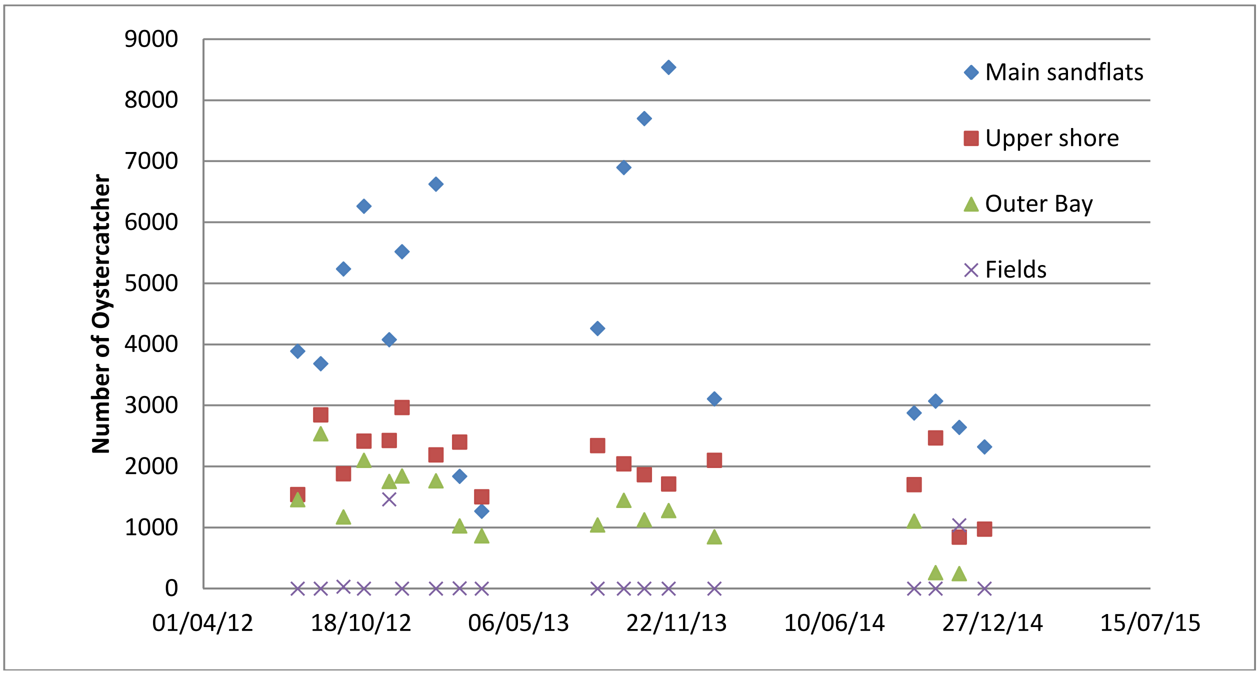

Figure 27. Monthly low tide oystercatcher counts July 2012-December 2014.

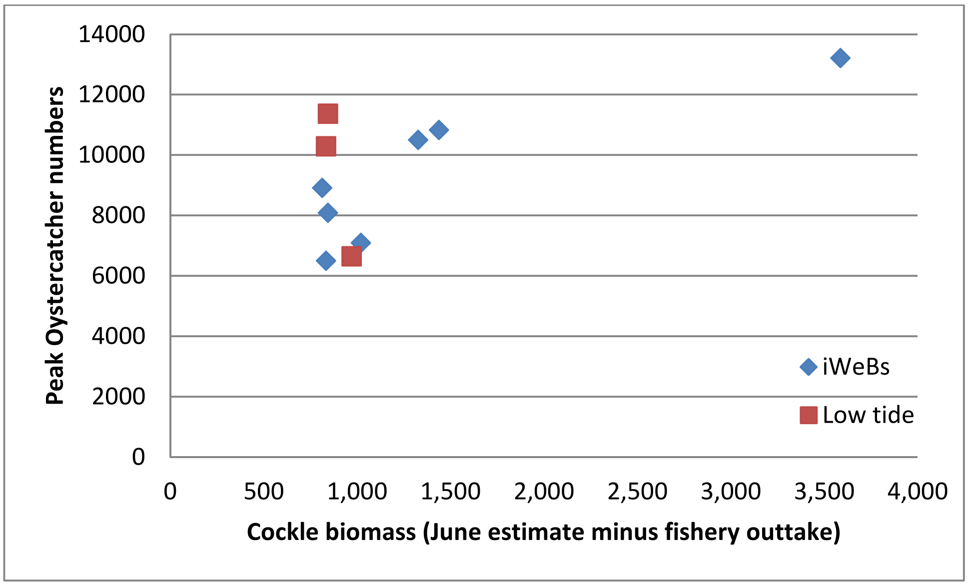

Figure 28. Relationship between peak oystercatcher numbers in autumn-winter and post fishery cockle biomass in the previous autumn. Fishery outtake in some years is zero. iWeBs is high tide count data.

8 Oyster (*Ostrea edulis*)

8.1 Management advice

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

A commercial fishery for Pacific oyster has occurred in Lough Swilly in recent years. This is preventing the build up of aggregations of the species although the fishery is limited to certain areas only.

Generally, although seasonal quotas and minimum size regulations are in place for some fisheries, management plans or recovery plans should be developed in order to restore productivity to stocks.

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

8.2 Issues relevant to the assessment of the oyster fishery

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

Recruitment is variable in most areas although settlement occurred in all areas surveyed in 2014. Larval production and settlement is conditional on density of spawning stock, high summer temperatures and the availability of suitable settlement substrate.

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

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

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

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

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

All the main oyster beds in Ireland occur within Natura 2000 sites. Oyster is a characterising species of sedimentary habitats of large shallow inlets and bays. It can also be a key habitat forming species in conditions where recruitment rates are high and where physical disturbance is low.

Management of oyster fisheries will need to consider the conservation objectives for this species and its associated habitat where it occurs in Natura 2000 sites.

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.

8.3 Management Units

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

8.4 Survey methods

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

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

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

8.5 Tralee Bay

8.5.1 Distribution and abundance of native oyster in Fenit in 2013

A pre fishery survey was completed in September 10-11th 2013. A total of 76 tows (average length 60.70±7.74m) were taken on a pre-determined survey grid. The total area surveyed was 3.8 km^2 and 4,020 oysters were caught.

September 2013 densities, corrected for a dredge efficiency of 17.37%, ranged from 0-17.5 oysters per m^2, which is much lower than the density range recorded in September 2012 (0-66 oysters per m^2) (Figure 29). The total number and biomass of oysters in the survey area was estimated to be 15.36 million and 1,026±145 tonnes, respectively (Table 18). The total number of oysters was less than half the total number estimated in September 2012 at 33.71 million. Approximately 11.7% (120 tonnes) of the biomass was equal to or over the minimum landing size of 78 mm.

Oysters ranged in size from 7-115 mm and averaged±sd 64.71±13.30 mm in shell length. A significant proportion of the stock was approaching the minimum size of 78 mm (Figure 30) but with little evidence of recruitment in 2013 or in 2011-2012.

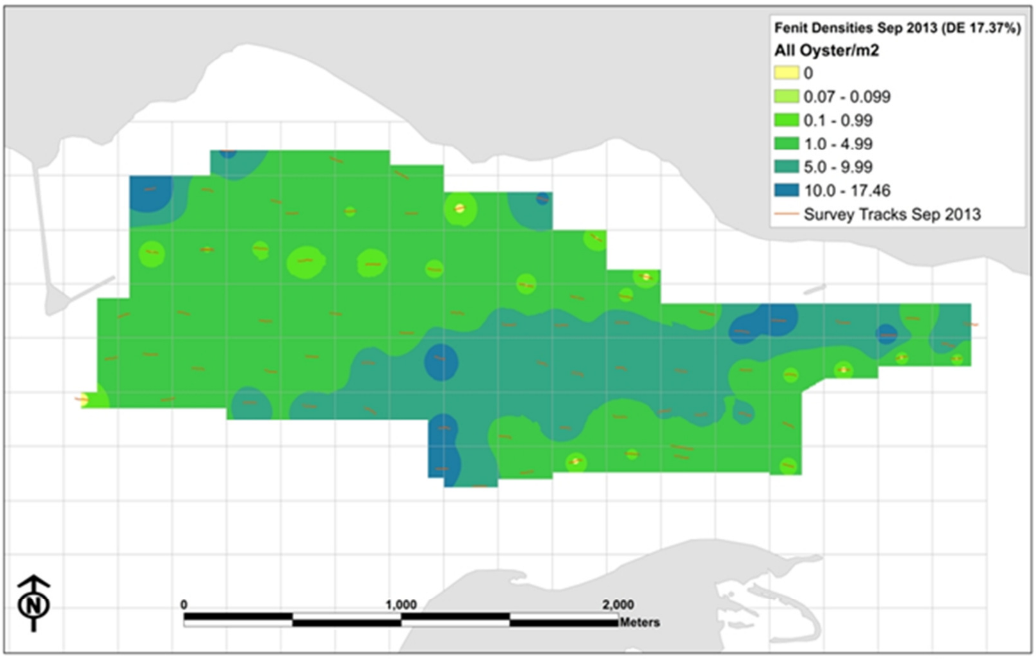

Figure 29. Density and distribution of native oyster in Fenit September 2013.

Table 18. Density distribution and biomass of native oysters in Fenit in September 2013 corrected for dredge efficiency of 17.37%.

Density All Oysters (DE 17.37%)	Area (m^2)	N	Mean density (m^2)	95% CL density	Number of oysters	Biomass (gms m^2)	95% CL Biomass (m^2)	Total biomass (tonnes)	CL Biomass (tonnes)
0	3881	7	0.00	0.00	0	0.00	0.00	0.00	0.00
0.07 - 0.099	2019	3	0.08	0.01	162	5.22	0.52	0.01	0.00
0.1 - 0.99	140550	11	0.69	0.15	96332	56.07	11.98	7.88	1.68
1.0 - 4.99	2355618	27	2.41	0.36	5675321	172.21	25.54	405.66	60.17
5.0 - 9.99	1109931	19	6.89	0.58	7648633	441.58	37.40	490.12	41.51
10.0 - 17.46	148888	9	13.01	4.45	1937580	824.15	281.93	122.71	41.98
	3.76km^2	**76**			**15358028**			**1026**	**145**

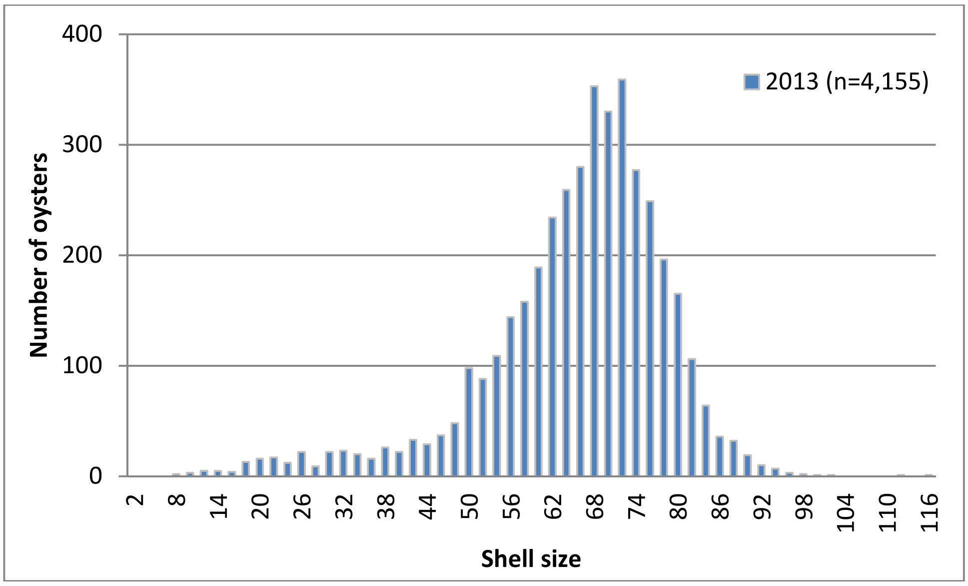

Figure 30. Size distribution of oysters in Fenit in 2013.

8.5.2 Distribution and abundance of native oyster in Fenit in 2014

A pre fishery survey was completed in September 17-19th 2014. A total of 71 tows (average length 56m±13 m) were taken on a pre-determined survey grid. The total area surveyed was 3.8 km^2 and 6,813 oysters were caught. A smaller survey was completed in outer Tralee Bay; biomass estimates were very low and are not presented as densities.

Biomass ranged from 0 to 873 g.m^{-2} of oysters. The total biomass of oysters in the survey area, uncorrected for dredge efficiency, was 446 tonnes. Using a dredge efficiency of 17.37% gives a total estimated biomass of 2,567 tonnes and a biomass of approximately 1,400 tonnes at dredge efficiency of 35% (used in other oyster beds).

Biomass of oysters over 78 mm in size was estimated separately. Six density classes were recognised (including 0). Maximum density of commercial oysters was 58 m^{-2}. This was exceptional however. The coefficients of variation of the estimates were high, averaging 82%, due to the patchy distribution of commercial sized oysters. Estimated biomass (tonnes) of commercial oysters was 45.6 tonnes not accounting for dredge efficiency and approximately 257 tonnes using a dredge efficiency of 17.5% (Table 20). This estimate is just above the total commercial removals in 2014 of 240 tonnes. However, it is known from pre and post fishery surveys that the fishery has the capacity to remove very high proportions of the commercial sized stock during the fishing season.

The size distribution data showed evidence of significant settlement in 2014 (6-12 mm oysters) and also significant numbers of oysters which are probably 1 and 2 years of age (Figure 32). These were not evident in the 2013 survey. In outer Tralee Bay there was also evidence of a 2014 settlement in addition to oysters >100 mm shell size (Figure 33).

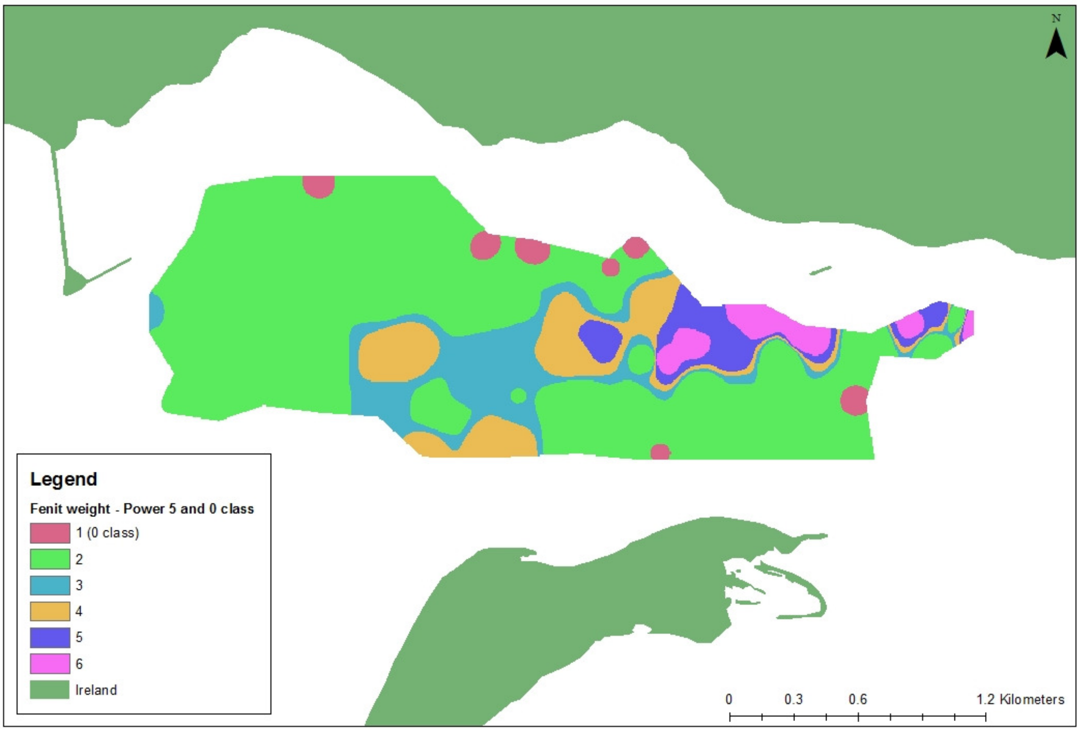

Figure 31. Distribution of biomass of oysters in Fenit in 2014. See for biomass categories associated with classes 1-6 shown.

Table 19. Biomass of native oyster in Fenit in September 2014.

Grid code	Grid classes (grams.m^{-2})	Grid area (m^2)	N (tows)	Average Grams. m^{-2}	Std.Dev of grams_ m^{-2}	Biomass (tonnes)	CV%
1	0.000185-0.36	1395	8	0.00	0.00	0.00	0.00
2	0.36-70.0	1242810	28	31.27	23.84	38.87	76.24
3	70.0-150	840944	13	109.33	27.81	91.94	25.44
4	150-243	655633	5	175.71	35.94	115.20	20.45
5	243-376	310396	7	291.63	39.25	90.52	13.46
6	376-544	169885	4	483.10	31.83	82.07	6.59
7	544-873	41314	6	682.01	118.43	28.18	17.37
Grand Total		**1242810**	**71**	**158.33**	**206.65**	**446.77**	**27.12**
					Total biomass (accounting for dredge efficiency)	**2567**	

Table 20. Biomass of commercial sized oysters in Fenit in September 2014.

		g.m^{-2}>78mm		Biomass	CV%
Density class	Area (m2)	Mean	S.d.	(tonnes)	
0	415555	0.042		0.02	
12	1197405	7.077	12.694	8.47	179
18.6	807693	15.208	11.690	12.28	77
26.8	445887	22.540	13.649	10.05	61
40.9	299972	32.119	15.049	9.63	47
58	95930	54.042	23.976	5.18	44
				45.64	82
Total biomass (tonnes) >78mm				**257**	

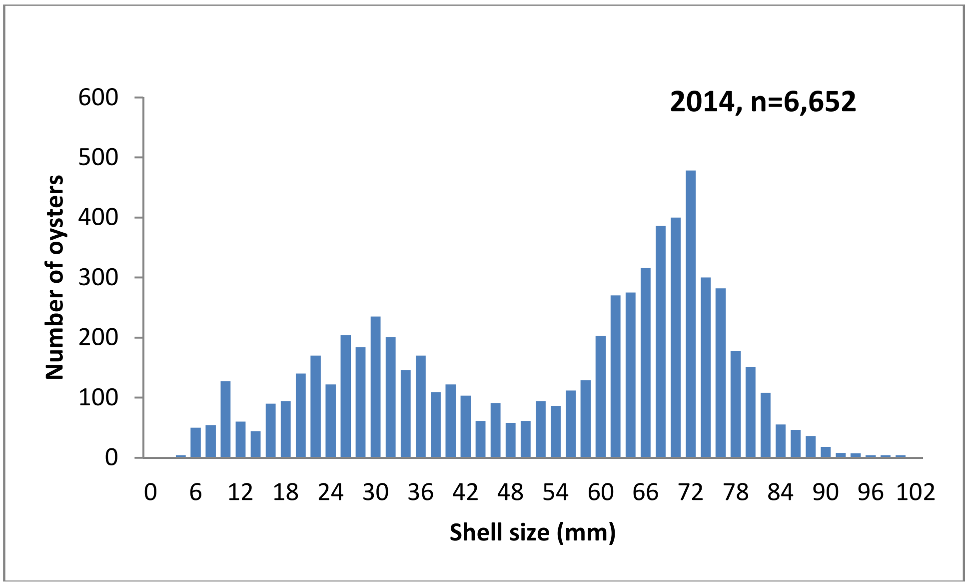

Figure 32. Size distribution of oysters in Fenit in September 2014.

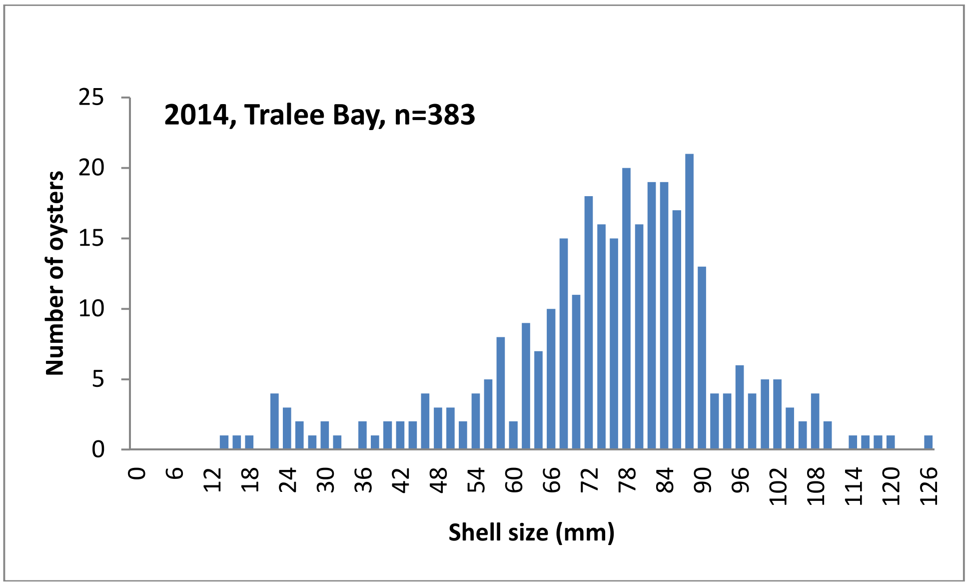

Figure 33. Size distribution of oyster in Tralee Bay in September 2014.

8.6 *Lough Swilly*

8.6.1 Distribution and abundance of native oyster in 2013

Estimated biomass of native oyster in a survey area of approximately 9 km^2 in October 2013 was 212 tonnes (Table 21). Densities, uncorrected for dredge efficiency ranged from 0-1.35 (Figure 34). Modal size was 60 mm (Figure 35). The fishery was operating during the survey.

Table 21. Biomass of native oyster in Lough Swilly in October 2013.

Survey area	Area m^2	Tonnes of native oyster
Ballybegley	2241784	65.7
Ballygreen	3515859	97.6
Ballymoney	471733	5.1
Ramelton	2737127	43.6
	8.96km^2	**212**

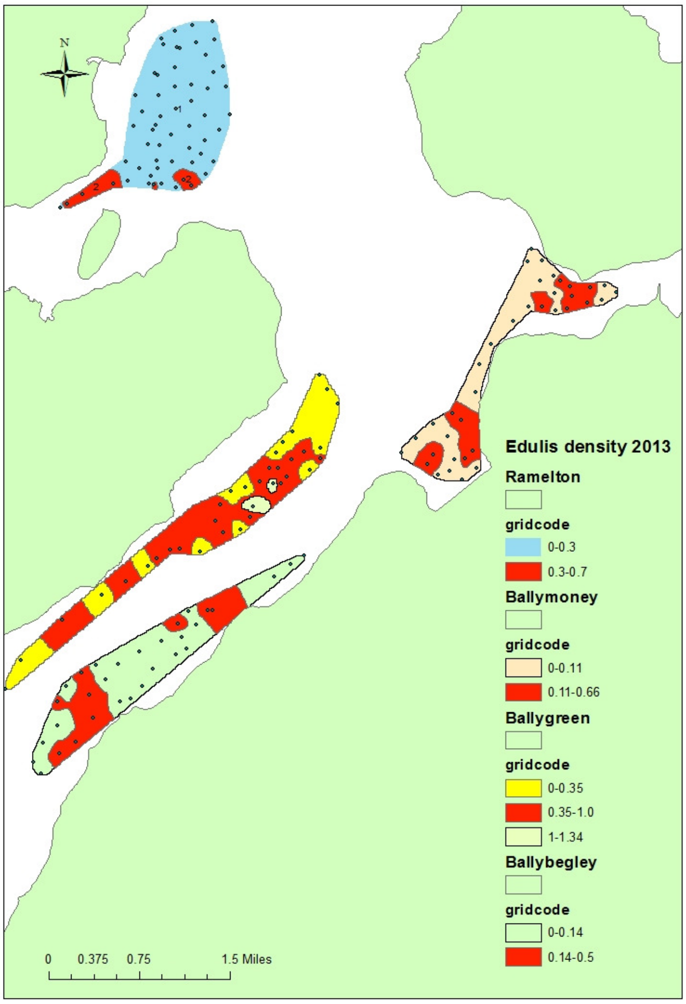

Figure 34. Interpolated distribution and density of native oyster in Lough Swilly in October 2013 (densities not corrected for dredge efficiency).

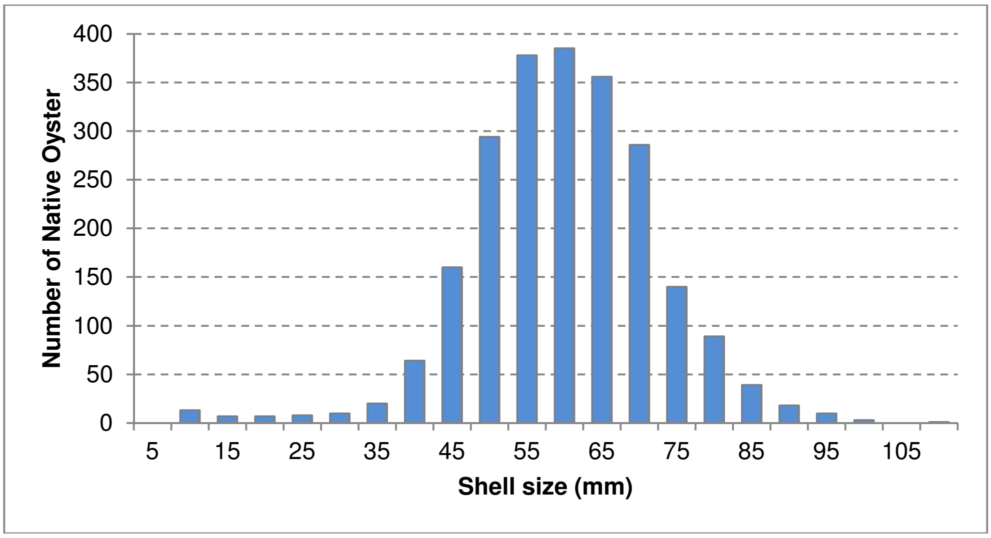

Figure 35. Size distribution of native oyster in Lough Swilly, in 2013.

8.6.2 Distribution and abundance of native oyster in 2014

Estimated biomass of native oyster in a survey area of approximately 13 km^2 in October 2014 was 209 tonnes (Table 22). Densities corrected for dredge efficiency ranged from 0-12 oysters m^{-2}. Densities were highest at Ballybegley and Ballygreen (Figure 36). Modal size was 45 mm with a lesser mode at 65 mm (Figure 37). The fishery was operating during the survey.

Table 22. Survey area and biomass of Native oysters within the survey area in Lough Swilly in October 2014.

Survey area	Area (km^2)	Biomass (tonnes)
Ballybegley	2.24	63.7
Ballygreen	3.51	97.5
Ballymoney	4.71	4.9
Ramelton	2.73	43.6
Total	**13.19**	**209**

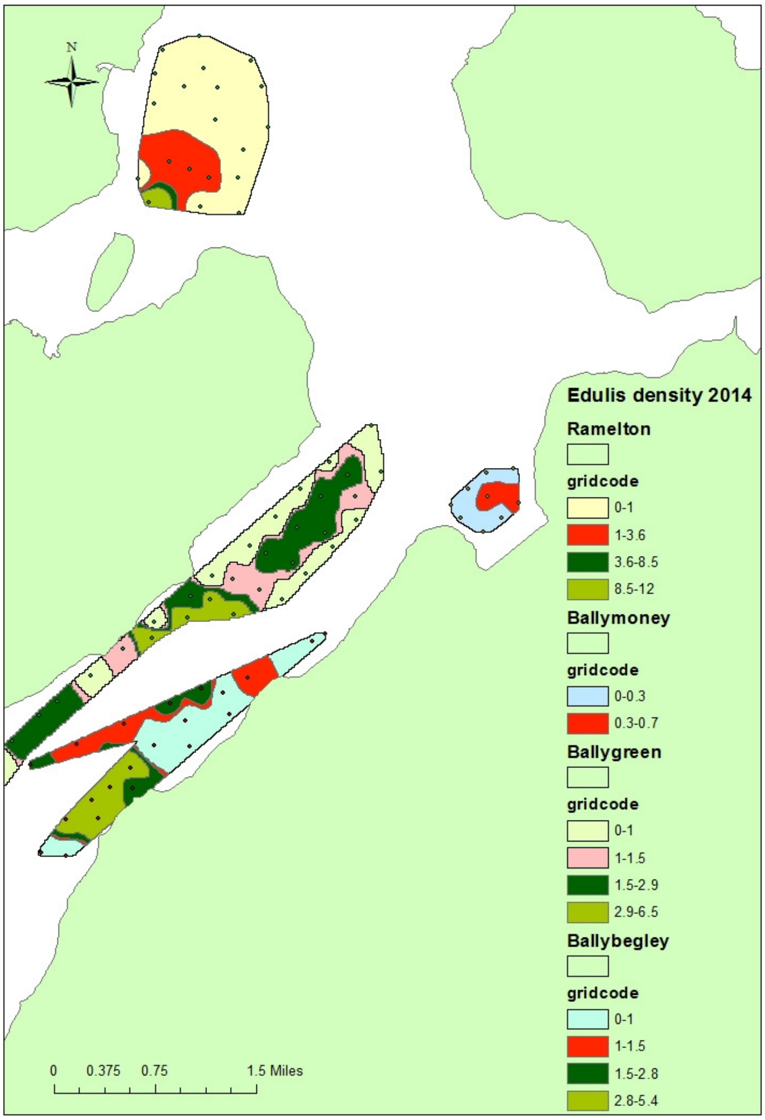

Figure 36. Interpolated distribution and density of native oyster in Lough Swilly in October 2014 (corrected for dredge efficiency).

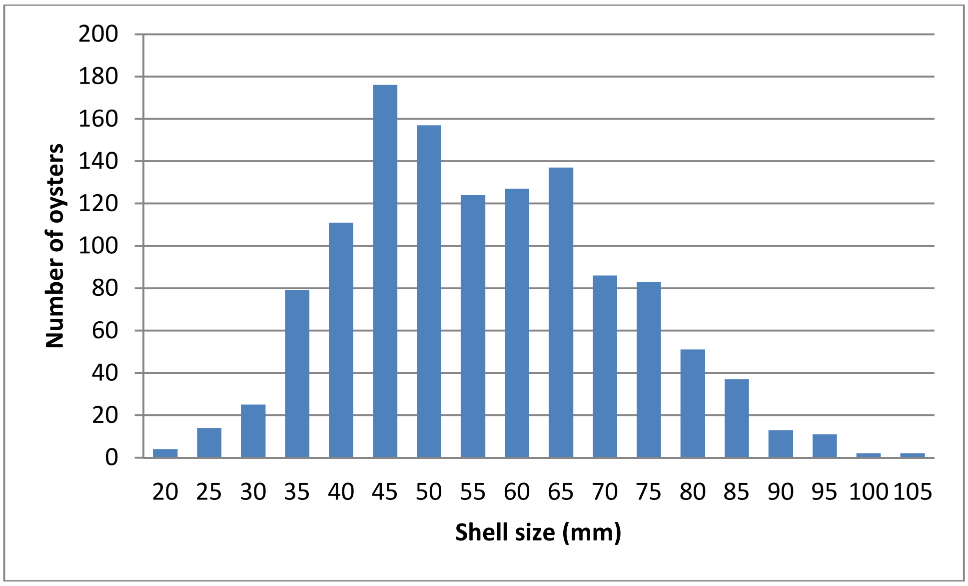

Figure 37. Size distribution of native oyster in Lough Swilly, in 2014.

8.6.3 Distribution and abundance of Pacific oyster in 2013

The estimated number of Pacific oysters in the survey area of 9.6 km² in 2013 corrected for dredge efficiency and 2.1 million corrected for a dredge efficiency of 35% (Table 23). Highest densities occurred at Ramelton and Ballybegley (Table 23, Figure 40). Size range varied from approximately 20 mm to over 200 mm with modes between 75-120 mm (Figure 39).

Table 23. Survey area and number of Pacific oysters within the survey area in Lough Swilly in October 2013.

Survey area	Area m^2	Number of oysters	Density.m^{-2}
Ballybegley	2363935	203964	0.09
Ballygreen	2635624	182553	0.07
Ballymoney	1841977	33157	0.02
Ramelton	2769341	334972	0.12
Total	9.61km^2	754646	

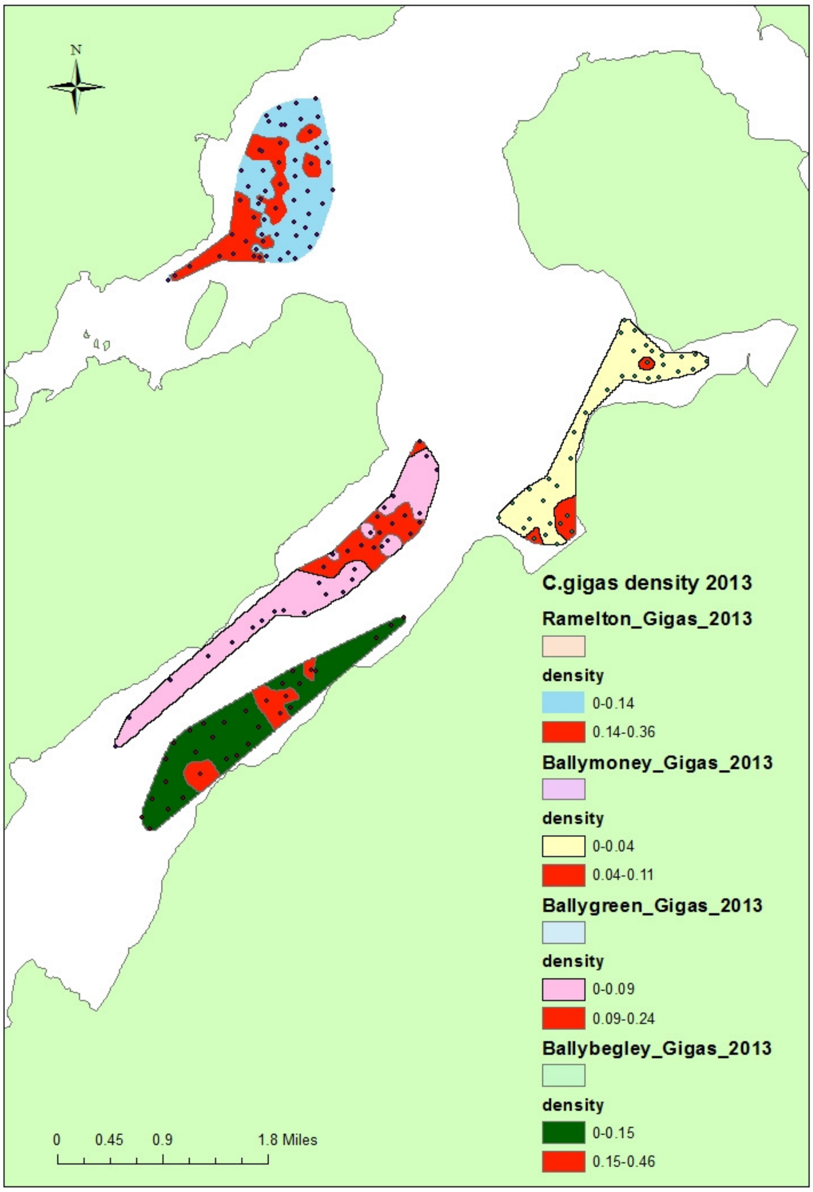

Figure 38. Interpolated distribution and density of Pacific oyster in Lough Swilly in October 2013.

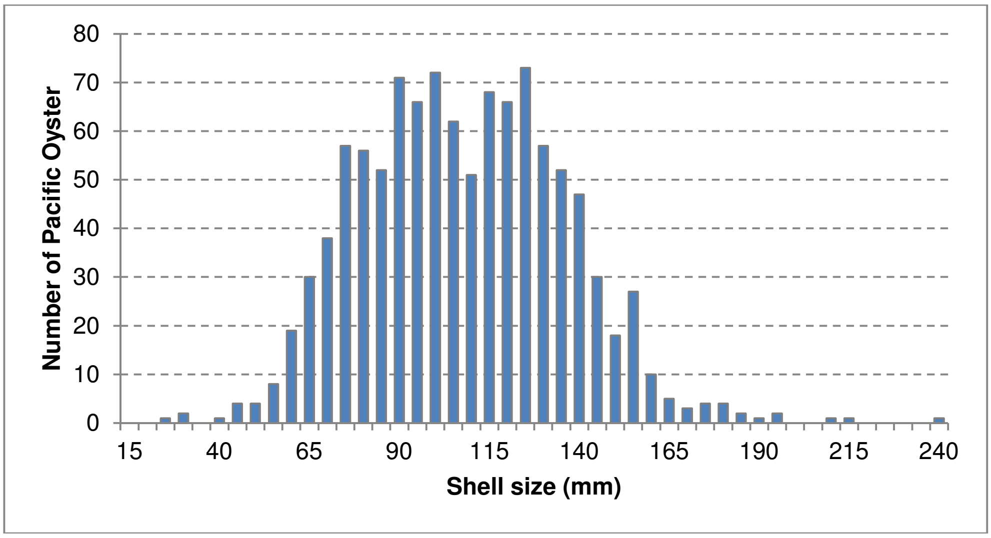

Figure 39. Size distribution of pacific oysters in Lough Swilly, 2013.

8.6.4 Distribution and abundance of Pacific oyster in 2014

The estimated population of Pacific oyster in the survey area of 9 km² was 3.35 million. Highest densities were recorded at Ballygreen and Ramelton (Table 24, Figure 38). The size distribution was clearly bi-modal with modes at 50 mm and 120 mm (Figure 41). The smaller size group were not recorded in 2013.

Table 24. Density and estimated number of C. gigas in 4 areas of Lough Swilly in October 2014.

Survey Area		Density		
	Area m^2	Average	S.d.	Total number
Ballybegley				
0-0.41	1066697	0.09	0.11	98085
0.41-1.03	1175086	0.68	0.22	799189
Ballygreen				
0-0.37	1961359	0.13	0.11	245760
0.37-1.0	1346671	0.59	0.17	787891
1-3.11	207829	2.86	0.36	594874
Ballymoney				
0-0.19	421738	0.04	0.06	15364
0.19-0.14	49995	0.41		20267
Ramelton				
0-0.46	2319520	0.16	0.14	367505
0.46-1.01	473580	0.89	0.15	422265
Total	**9km²**			**3351199**

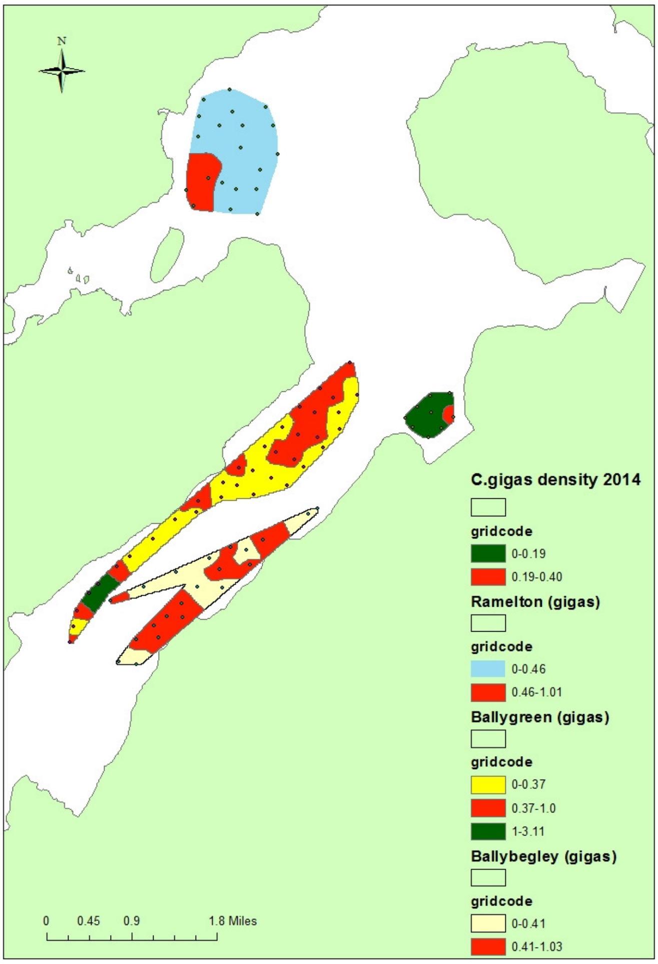

Figure 40. Interpolated distribution and density of Pacific oyster in Lough Swilly in October 2014.

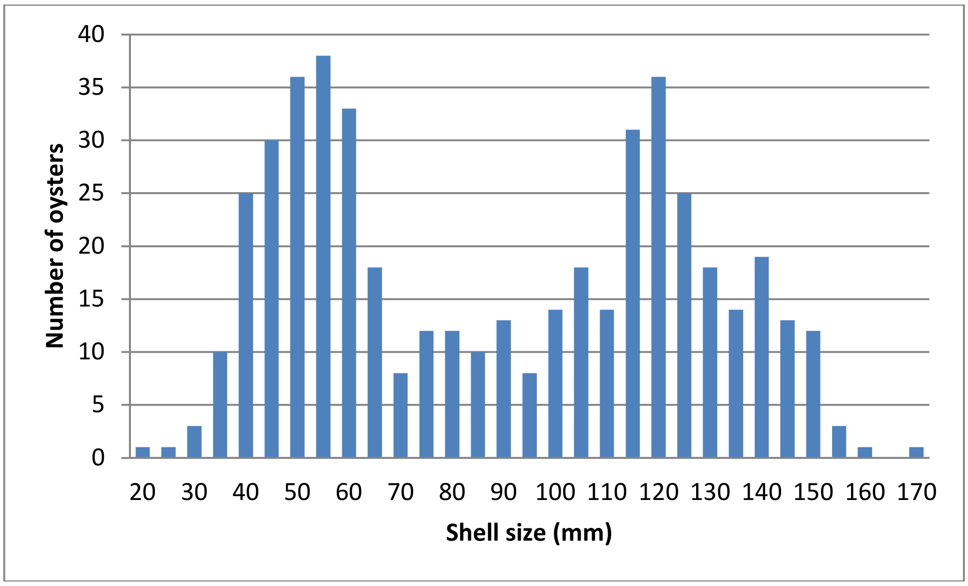

Figure 41. Size distribution of pacific oysters in Lough Swilly, October 2014.

8.7 Galway Bay

8.7.1 Distribution and abundance of the native oyster in 2013

A pre-fishery survey was completed on the 12th November 2013 in inner Galway Bay. A total of 51 tows were completed, 37 of which were located on the main bed in Rincarna Bay. Ten tows were completed further south, along Rincarna spit and four were located in the fishery order area, up river from the main fishing grounds. The total area surveyed was approximately 1.02 km^2 in extent and 1,463 oysters were captured. All oysters were measured.

Oyster densities, corrected for 35.5% dredge efficiency, ranged from 0-3.54 oysters per m^2. The total number and biomass of oysters in the survey area was estimated to be 1.4 million and 43.8±17.73 tonnes, respectively (Table 25). Approximately 8.8% (11 tonnes) of this biomass was over the minimum landing size of 76 mm

The average shell size was 51.7±17.6 mm, ranging from 11-104 mm. The modal shell size was 56 mm, 16 mm smaller than in November 2012.

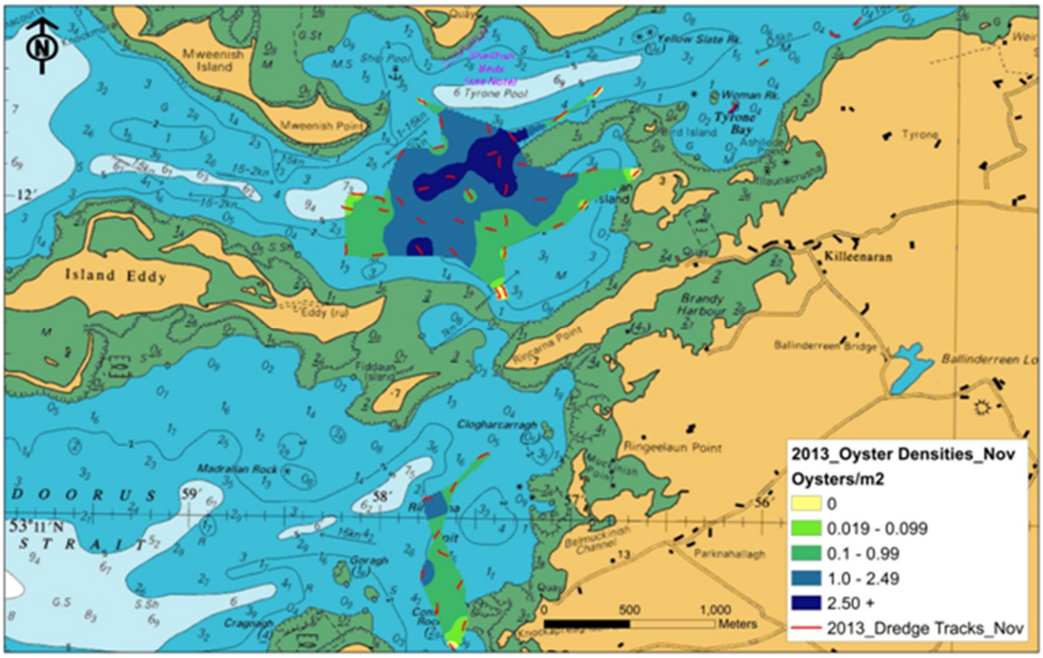

Figure 42. Distribution and density of native oysters in south east Galway Bay November 2013.

Table 25. Distribution of native oyster biomass in south east Galway Bay in November 2013 assuming a dredge efficiency of 35.5%.

Density (DE=35.5%)	Area (m^2)	N	Mean density (m^2)	S.d.	95% CL density	Number of oysters	Biomass (gms m^2)	95% CL Biomass (m^2)	Total biomass (tonnes)	CL Biomass (tonnes)
0	11531	8	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00
0.019 - 0.099	32908	4	0.038	0.005	0.005	1234.03	2.88	1.26	0.09	0.04
0.1 - 0.99	379991	16	0.536	0.268	0.131	203769.97	18.69	8.91	7.10	3.38
1.0 - 2.49	454536	15	1.647	0.446	0.226	748771.60	49.86	17.74	22.67	8.06
2.50 +	143201	8	3.216	0.261	0.181	460568.76	97.30	43.58	13.93	6.24
	1.02km²	**51**				**1414344**			**43.8**	**17.7**

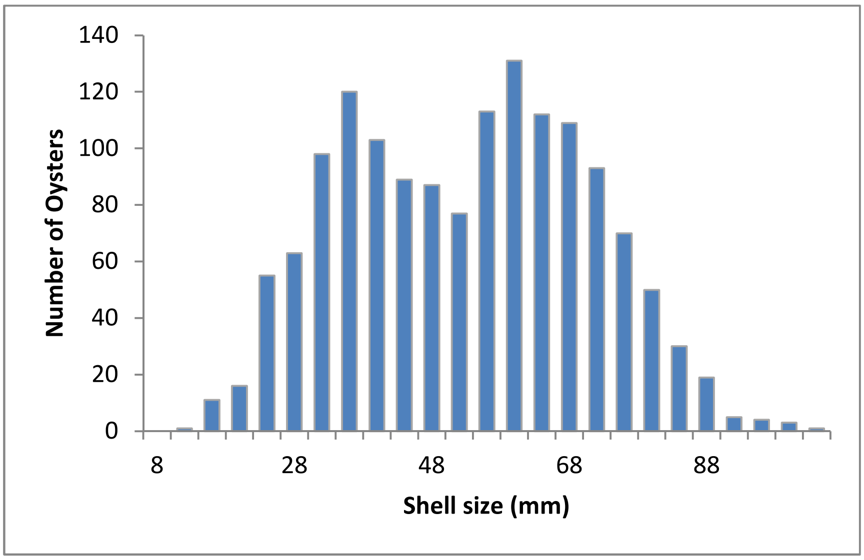

Figure 43. Size distribution of native oysters in south east Galway Bay in 2013.

8.7.2 Distribution and abundance of the native oyster in 2014

A pre-fishery survey of Galway Bay native oyster was undertaken in November 2014. A total of 21 tows were completed on the main oyster bed in Rincarna Bay (Figure 45). The total area surveyed was approximately 0.91 km² and 1,127 oysters were collected and measured. Densities of oysters corrected for 35.5% dredge efficiency ranged from 0-8.73 oysters per m². However, the highest density of 8.73 oyster per m² was only recorded from one station, with the majority of stations returning densities ranging between 0-3.57 oysters per m². The total number and biomass of native oysters estimated in the survey area were 14.7 million and 59.67±2.57 tonnes, respectively (Table 26). Approximately 3.85 tonnes of the estimated 2014 biomass was over the minimum landing size of 76 mm.

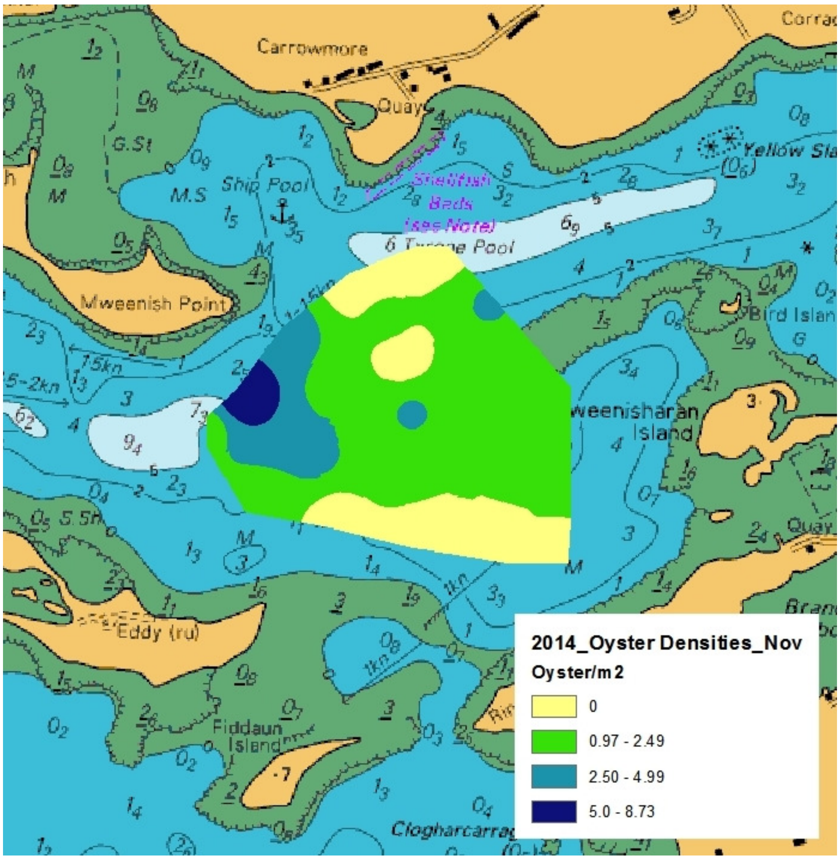

Figure 44. Distribution and density of native oysters in south east Galway Bay November 2014.

Table 26. Distribution of native oyster biomass in south east Galway Bay in November 2014 assuming a dredge efficiency of 35.5%.

Density (DE=35.5%)	Area (m^2)	N	Mean density m^2	St. Dev	95% CL density	Number of oysters	Biomass (gms m^2)	95% CL Biomass m^2	Total biomass (tonnes)	CL Biomass (tonnes)
0	221694	7								
0.9 - 2.49	540204	9	1.62	0.38	0.09	875131	67.53	3.61	36.48	1.95
2.5 - 4.99	120565	4	3.04	0.37	0.12	366517	118.75	4.97	14.32	0.60
5.0 - 8.73	26025	1	8.73	0.00	0.00	227202	325.38	0.78	8.47	0.02
	0.91 **km^2**					**1468850**			**59.26**	**2.57**

The average shell size was 56.6±17.8mm, slightly higher than that recorded in 2013 (51.7±17.6 mm), ranging from 7-102 mm.

The modal shell size was 70 mm, 14 mm larger than in November 2013.

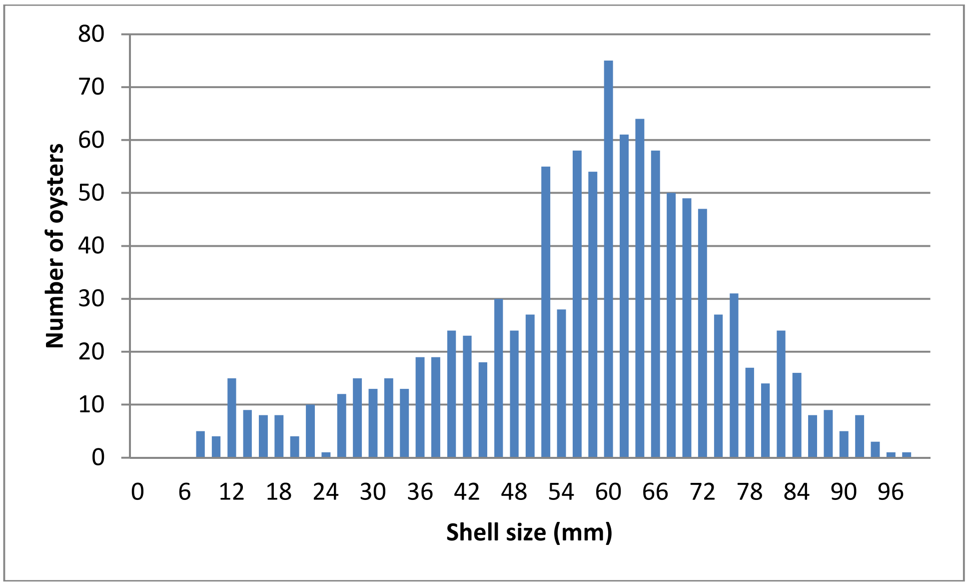

Figure 45. Size distribution of native oysters in south east Galway Bay in 2014.

9 Brown crab (*Cancer pagurus*)

9.1 Management advice

Catch rates of commercial crab in the inshore and offshore areas of the Irish fishery have declined slowly over the past 20 years and average between 0.5-1.5kgs per pot haul in all areas.

Size composition of the catch is stable. There is significant high grading above the legal MLS in the Irish fishery and given that the MLS is also well above the size at maturity there is probably adequate spawning escapement and recruitment is unlikely to be limited.

There are indications of over-exploitation and low biomass in some stocks in the North Sea and east and west of Scotland.

9.2 Issues relevant to the assessment of the brown crab fishery

9.2.1 The fishery

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

Landings increased exponentially between 1992 and 2004 and amounted to over 13,000 tonnes in 2004. Landings subsequently declined to approximately 6,500 although there is some doubt about recent official landings data. Data from questionnaires and other local sources suggests they are underestimated. Offshore effort has declined and in 2014 only 2 Irish vivier vessels fished offshore. Some of this effort occurred in the southern north Sea. The under 13 m fleet also fishes offshore off north Mayo and west of Donegal. On other coasts the fishery occurs largely inside 12 nm (Figure 46).

9.2.2 Methods

Two main methods are used internationally but in combination with ancillary information on biology and minimum size regulations

1. Length cohort analysis (LCA).
    a. Estimates of fishing mortality rate (F) are presented in a Yield per recruit and Biomass per recruit context
    b. Estimates F and reconstructs the population biomass using landings data
2. Trends in stock status indicators
    a. LPUE, DPUE and CPUE (landings, discards, catch per unit effort indicators derived from commercial fleet data)
3. Ancillary information
    a. Trends in landings, effort, size composition, size at maturity

relative to minimum landing size regulation or effective landing size

9.2.3 Assumptions and limitations

1. LCA
   a. Stock is in equilibrium
   b. Size composition is responsive to changes in fishing effort
   c. Growth data is generally poor, natural mortality is unknown
2. Trends
   a. Changes in indicators are proportional to changes in stock abundance

9.2.4 Reference points

The exploitation rates (fishing mortality rates, F) and stock levels (spawning biomass per recruit or spawning stock biomass, SSB) estimated in the assessments are reported in relation to reference points or management limits and targets for the stock.

1. **F** reference points
   a. F_{msy} or the fishing mortality that will result in B_{msy} in the long term
   b. F_{max} (proxy for F_{msy} derived from the yield per recruit approach) and indicates the F at which YPR is at a maximum
2. **Stock** reference points
   a. Target: SPR35% or the spawning potential per recruit that produces 35% of the unexploited level of egg production. This is a proxy for B_{msy}. Managing F at a level that maintains SPR35% should, in the long term produce B_{msy}.
   b. Limit: Defined as $0.5B_{msy}$.
   c. Catch rate indicators are assumed to be proxies for stock status but reference levels for these indicators are not defined (other than in the Shetland stock where they are arbitrarily identified in NAFC assessments in relation to the MSC standard).

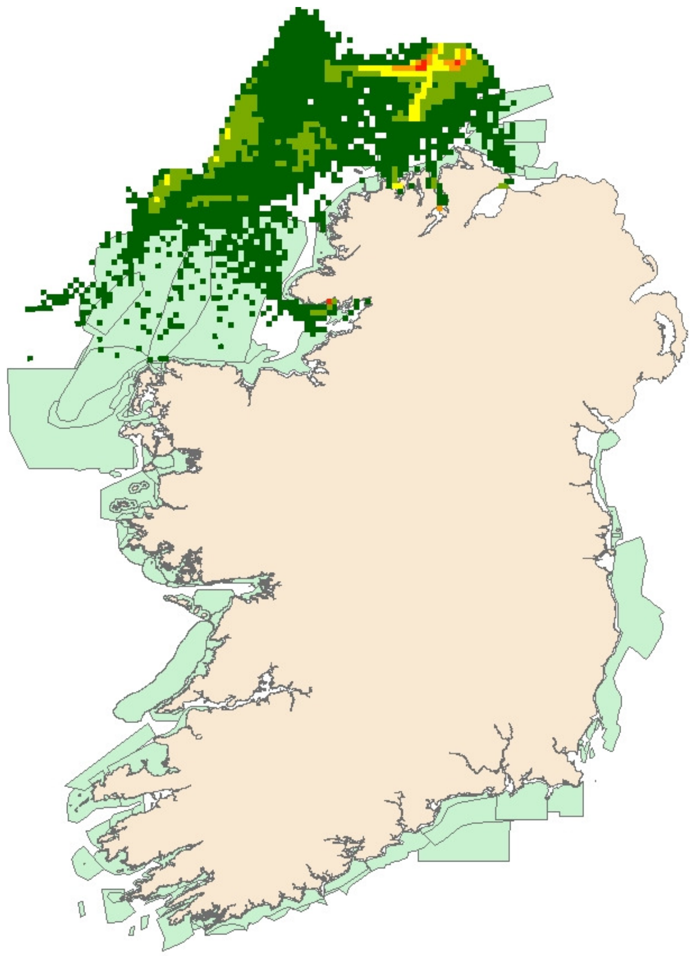

Figure 46. Distribution of pot fisheries, including brown crab on the Irish coast. VMS data for vessels over 15m is shown in the north west.

9.3 ICES Assessment units

ICES (WG Crab) has identified stock units for the purpose of assessment (Figure 47). On the Irish coast these units are identified from tag return data, distribution of fishing activity and larval distribution.

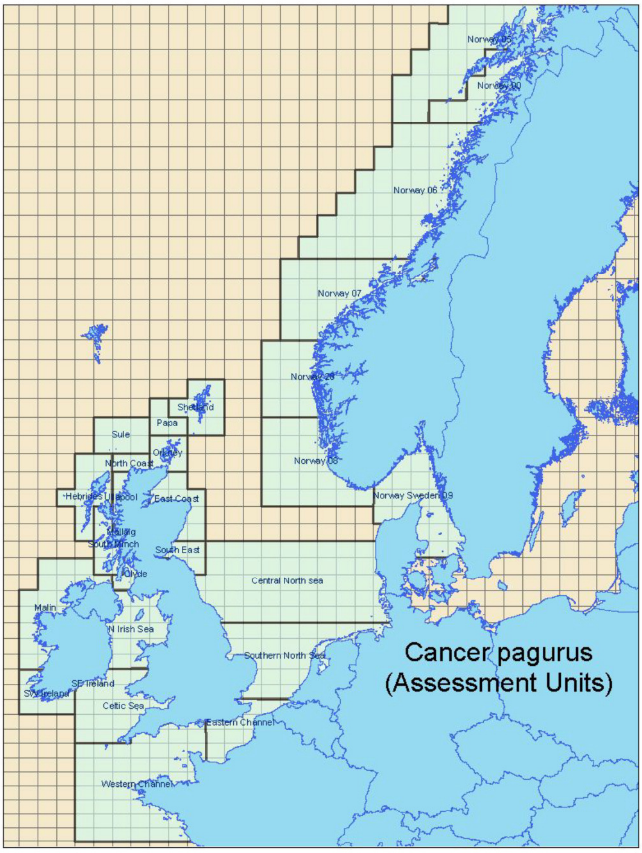

Figure 47. ICES stock assessment units for Brown crab.

9.4 Stock status summary for ICES units

The exploitation status (in relation to F_{msy}) and stock status (in relation to B_{msy} proxies or CPUE trends) for each stock assessment unit are shown in Table 27.

- Given the assumptions and uncertainties in the assessments the categorising of stocks as under or over exploited based on current F or SPR or CPUE and in relation to reference points which are also uncertain should be interpreted loosely.
- Other information such as the minimum landing size in force (in relation to size at maturity), and trends in fishing effort should be used in parallel.
- Stocks in the north Irish Sea , Clyde and Ullapool have not been assessed
- Stocks in the English Channel, Celtic Sea, SW Ireland, Malin do not appear to be overexploited and stock status is stable
- Stocks in the North Sea, East of Scotland, Orkney and some stocks on the west coast of Scotland show evidence of over exploitation
- Different minimum landing sizes apply in different areas. Size at 50% maturity is below the size at first capture.

Table 27. Summary of exploitation status and stock status for 20 stock assessment units (Figure 1). Stock status; High = close to or at biomass target reference point, Moderate = between biomass target and limit reference points, Low = at or below biomass limit reference point, Stable = in relation to trends in CPUE. Source: published assessments from Marine Scotland and CEFAS, trend indicators MI.

				Exploitation status		Stock status		MLS	
				F (in relation to F_{msy})					
ICES	**Stock Assessment Unit**	**Main Fleets**	Assessment	Male	Female	Male	Female	Male	Female
VII	Western Channel	England, France	LCA	F<Fmsy	F<Fmsy	High	High	140-160	140-150
VII	Eastern Channel	England, France	LCA	F=>Fmsy	F=>Fmsy	Moderate	Moderate	130-140	130-140
VII	Celtic Sea, SE Ireland	Ireland, UK, France	LCA, Trends	Unreported	F=>Fmsy	Unreported	High	130-160	130-150
VII	SW Ireland	Ireland	Trends	Unreported	Unreported	Stable	Stable	130	130
VII, VI	Malin	Ireland, N.Ireland, Scotland	Trends	Unreported	Unreported	Stable	Stable	130	130
VII	N Irish Sea	Ireland, IoM, Wales, England	Trends	Unreported	Unreported	Unreported	Unreported	130	130
VI	Clyde	Northern Ireland, Scotland	LCA per recruit	Unreported	Unreported	Unreported	Unreported	140	140
VI	South Minch	Scotland	LCA per recruit	F>Fmsy	F>Fmsy	Unreported	Unreported	140	140
VI	Mallaig	Scotland	LCA per recruit	Unknown	Unknown	Unreported	Unreported	140	140
VI	Hebrides	Scotland	LCA per recruit	F<Fmsy	F>Fmsy	Unreported	Unreported	140	140
VI	Ullapool	Scotland	LCA per recruit	Unknown	Unknown	Unreported	Unreported	140	140
VI	North Coast	Scotland	LCA per recruit	F<Fmsy	F<Fmsy	Unreported	Unreported	140	140
VI	Sule	Scotland	LCA per recruit	F=Fmsy	F>Fmsy	Unreported	Unreported	140	140
IV	Orkney	Scotland	LCA per recruit	F>Fmsy	F>Fmsy	Unreported	Unreported	140	140
IV	Papa	Scotland	LCA per recruit	F<Fmsy	F<Fmsy	Unreported	Unreported	140	140
IV	Shetland	Shetland	LCA per recruit	F=Fmsy	F<Fmsy	Unreported	Unreported	140	140
IV	East Coast	Scotland	LCA per recruit	F>Fmsy	F>Fmsy	Unreported	Unreported	140	140
IV	South East	Scotland, England	LCA per recruit	F>Fmsy	F>Fmsy	Unreported	Unreported	130	130
IV	Central North Sea	England, Ireland	LCA	F>Fmsy	F>Fmsy	Low	Low	130-140	130-140
IV	Southern North Sea	England, Ireland	LCA	F>Fmsy	F>Fmsy	Low	Low	115-130	115-130

10 Glossary

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TAC Total Allowable Catch

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

VMS Vessel Monitoring System