Shellfish Stocks and Fisheries Review

December 2011






BIM
Bord Iascaigh Mhara
Irish Sea Fisheries Board

Marine Institute
Foras na Mara

Shellfish Stocks and Fisheries

Review 2011

An assessment of selected stocks

The Marine Institute and Bord Iascaigh Mhara

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Irish Sea Fisheries Board

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Photographs on cover by J. White (crayfish), R. Pillon (shrimp)

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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 (<13m) and landings for all species of shellfish (excluding Nephrops) are presented. The intention of the annual reviews 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 conservation areas designated under European Directives. The review reflects the recent work of the Marine Institute (MI) and An Bord Iascaigh Mhara (BIM) in the assessment and management of shellfisheries.

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

Shellfish stocks are not generally assessed by The International Council for the Exploration of the Sea (ICES) and although they come under the competency of the Common Fisheries Policy they are generally not regulated by TAC and in the main, are distributed inside the national 12nm territorial limit. Management of these fisheries, by the Department of Agriculture, Food and Marine (DAFM), is based mainly on minimum landing sizes and generally, but with exception, there are no input or output controls. A co-operative management framework introduced by the Governing Department and BIM in 2005 (Anon 2005) is now in abeyance and management proposals developed by the various advisory groups during the period 2005-2008 have not been implemented. 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, DCENR, IFI and fishing co-operatives with responsibility for management of shellfisheries in inshore waters.

2 Fishing Fleet

2.1 The Shellfish Fleet

The Irish fishing fleet is, for the purpose of licencing, divided into a number of segments. Vessels in the polyvalent segment, which contains the majority of vessels, have general access to the majority of shellfish stocks although access to a number of these stocks may be further restricted and require a specific authorisation. Vessels in the specific segment can only fish for bivalves while vessels in the potting segment can only use pots and, therefore, can only target crustaceans and whelk.

Vessels in the polyvalent segment, targeting shellfish, are generally less than 13m in length. Vessels licenced for potting only, targeting crustaceans and whelk, are all less than 12m in length (and <20Gt) as this was a condition of incorporating these vessels into the registered fleet in the period 2004-2006. All vessels in the aquaculture and specific segments target bivalves and vary from small oyster dredgers working inshore to offshore seed mussel and scallop dredgers.

The shellfish fleet, as defined above, numbered 1,959 vessels as indicated on the National Register of Sea Fishing Vessels on December 5th 2011 (Table 1). In addition 4 polyvalent vessels over 18m in length fish for crab offshore and 2 polyvalent vessels and 2 vessels in the beamer segment over 13m in length target scallop off the south east coast. An unknown number of vessels registered in Northern Ireland (on the UK fleet register) and not included in Table 1, also fish shellfish stocks in Irish inshore waters.

The number of vessels under 13m increased by 62% between 2006 and 2011. 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 licenced areas. The number of vessels in the polyvalent potting and specific segments declined by 20 and 9 vessels, respectively, in the period 2010-2011. The polyvalent general fleet increased by 137 vessels, 67 vessels and 59 vessels in 2009, 2010 and 2011, respectively.

The average length and capacity of vessels in the specific and aquaculture segments declined between 2006 and 2011. Vessel length and capacity in the polyvalent segment declined during the period 2006-2010 but increased in 2011.

Polyvalent potting vessels have higher engine capacities in proportion to their gross tonnage than polyvalent general vessels (Table 1). Aquaculture and specific vessels have lower engine capacities compared to polyvalent or potting vessels.

Table 1. Length and capacity profile of the Irish Shellfish fleet (<13m length) 2006-2011 (excluding 4 vivier crabbers and a number of polyvalent scallop vessels > 13m).

Segment	2006	2007	2008	2009	2010	2011
Aquaculture	16	21	39	73	86	96
Polyvalent General	953	950	994	1131	1198	1257
Polyvalent Potting	80	492	490	481	467	461
Specific	157	117	128	154	150	145
Grand Total	1206	1580	1651	1839	1901	1959
Average length of vessels						
Aquaculture	31.62	30.00	21.51	14.75	13.33	12.78
Polyvalent General	7.95	7.89	7.82	7.67	7.57	7.63
Polyvalent Potting	7.32	6.74	6.76	6.71	6.67	6.64
Specific	14.70	13.40	13.22	12.09	12.06	11.71
Average Gross Tonnage of vessels						
Aquaculture	212.05	197.86	117.30	64.18	54.12	48.87
Polyvalent General	4.68	4.61	4.38	4.14	3.96	4.30
Polyvalent Potting	2.96	2.28	2.30	2.22	2.16	2.12
Specific	38.62	27.34	25.93	20.54	20.29	18.55
Average kilowattage of vessels						
Aquaculture	468.55	433.79	284.45	166.11	142.51	132.04
Polyvalent General	35.49	36.46	34.05	31.77	30.43	31.73
Polyvalent Potting	44.50	29.60	30.29	29.70	28.93	28.28
Specific	162.81	124.53	113.26	96.36	94.26	90.32
Kilowatts per GT						
Aquaculture	2.21	2.19	2.42	2.59	2.63	2.70
Polyvalent General	7.58	7.91	7.77	7.68	7.69	7.38
Polyvalent Potting	15.03	12.99	13.20	13.39	13.41	13.32
Specific	4.22	4.56	4.37	4.69	4.65	4.87

3 Landings

3.1 Landings 2004-2010

Annual landings of crustaceans and bivalves, excluding *Nephrops* and wild blue mussel (*Mytilus*) seed, which is re-laid for on-growing, during the period 2004-2010 varied from 29,533 tonnes in 2004 to approximately 14,000 tonnes in 2008. The main decline in volume occurred in brown crab and whelk. Landings of scallop declined from a high in 2004 to a low in 2006 but recovered during 2007-2010 due to increased fishing activity in the eastern Celtic Sea and southern Irish Sea. Lobster landings declined from a high of 856 tonnes in 2004 to 308 tonnes in 2007 but recovered to 430-490 tonnes in 2008-2010 (Table 2). Edible crab, scallop and lobster were the most valuable species in 2010.

Decline in volume of crab between 2004-2010 was mainly due to falling market price, diverted fishing activity of the offshore vivier fleet to the southern North Sea, where crab are landed directly into the continent, and to initiatives by the industry to curb landings to stimulate market price. Lobster landings may have declined due to reduced fishing activity in response to poor market prices. Shrimp recruitment and catch rates were very poor in 2010 as reflected in the lowest annual landings for the 2004-2010 period. Native oyster and cockle landings fluctuate annually. Cockle fisheries are significantly affected by variability in recruitment which has been poor in recent years including 2010. Native oyster landings depend on local management decisions that are taken by the co-operatives in relation to the perceived state of the stocks locally and the stock decline due to *Bonamia* infection, low spawning stock biomass and poor recruitment.

The value of crustacean and bivalve fisheries was €43.2m in 2010.

Table 2. Annual landings (tonnes) and value (€) of crustacean and bivalve shellfish (excl. prawns and mussels) into Ireland 2004-2010 (source: Sea Fisheries Protection Authority). Scallop landings in 2009 have been allocated the 2008 figure. Unit value (per kilo) from 2010 sales note data except native oyster which is from oyster co-op sources. 2010 Spisula landings are from BIM logbook data for Waterford only. In descending order relative to 2010 value.

ScientificName	Common name	2004	2005	2006	2007	2008	2009	2010	2010	
									Unit Price	Value
Cancer pagurus	Edible crab	14,217	9,527	10,827	9,251	7,640	6,614	8,622	€1.49	€12,846,969
Pecten maximus	Scallop	2,471	1,277	742	953	1,322	2,685	1,982	€5.90	€11,691,437
Homarus gammarus	Lobster	856	635	625	308	498	431	477	€12.72	€6,067,409
Littorina littorea	Periwinkle	1,674	1,139	1,210	609	1,141	1,103	1,280	€2.04	€2,611,335
Buccinum undatum	Whelk	7,589	4,151	3,144	3,635	1,947	2,239	2,976	€0.83	€2,470,213
Palaemon serratus	Shrimp	405	151	319	325	180	228	135	€16.43	€2,219,447
Ostrea edulis	Native oyster	543	94	233	291	88	327	349	*€4.50*	€1,571,193
Aequipecten opercularis	Queen scallop	110	75	172	26	4		748	€1.70	€1,271,903
Necora puber	Velvet crab	291	245	281	142	268	205	342	€1.99	€680,333
Spisula	Surf clam	28		26	14	55	150	***162***	€3.00	€486,000
Maja brachydactyla	Spider crab	180	141	153	70	153	443	415	€1.08	€448,297
Palinurus elephas	Crayfish	80	30	34	16	18	28	30	€12.60	€379,816
Ensis	Razor clams	400	404	547	356	451	293	131	€2.64	€345,462
Chaceon affinis	Red crab	214	294	152	83	44	105	91	€1.08	€98,704
Carcinus maenas	Shore crab	268	27	46	91	72	244	129	€0.62	€79,960
Cerastoderma edule	Cockle	207	107	7	643	9	173	5	€1.70	€8,010
Veneridae	Venus clam		217	4						€0
Total		**29,533**	**18,513**	**18,522**	**16,815**	**13,892**	**15,269**	**17,874**		**€43,276,488**

4 Shrimp (*Palaemon serratus*)

4.1 Management recommendations

The fishing season closing date of May 31st should be changed to Feb 28th or earlier to protect mature female shrimp in early spring. Grading on board is important in optimising yields. Grading methods and practice should be further developed to increase discard survival. In season management of catch and effort based on catch rate indicators should be developed to conserve spawning stock. This is particularly important when recruitment is weak and given that there are only 2 age classes in the stock.

4.2 Issues relevant to the assessment and management of the shrimp fishery

- The fishery occurs between August 1st and February although the legal closing date is May 31st.
- There are usually 1-2 age classes in the stock at any time. The fishery is therefore recruitment dependent and relies on 1+ year old shrimp and also the 0+ age class, which are born in early summer and recruit to the fishery in October of the same year.
- The autumn fishery relies mainly on 1+ shrimp. The biomass of this cohort depends on its exploitation at 0+ age the previous autumn, overwintering mortality of 0+ shrimp and growth rate of this cohort during the summer prior to opening the fishery in August.
- There is a high proportion of mature (berried) shrimp (1+ females and some early maturing 0+ females) in the spring fishery.
- Recruitment variability is high and the fishery may have series of good and bad years.
- Stocks may be relatively isolated in individual bays and overexploitation of spawning stock (in particular 1+ females maturing in their second winter) poses a risk to larval production and recruitment in the following year.
- The number of pots generally exceeds 10,000 in Bays with significant fisheries. Total effort is related to fishery success; in a given season if catch is persistently poor effort may be taken out. However, this depends on market price and other fishing opportunities. Fishing may therefore persist when catch rate and stock biomass is at a low level. This effort is not managed.
- Given the short life span and variable recruitment the fishery can only be assessed, monitored and managed using in season, near real time, data. Strong stakeholder engagement and agreed management response points, based on fishery dependent indicators, are required to achieve this.

4.3 Management Units

Adult shrimp occur in shallow water generally less than 20m deep although they may overwinter in deeper water. Stocks occur in many coastal areas, but in particular in the north west Irish Sea, Helvick and Dunmore East, Youghal Hbr, Cork Hbr, Roaringwater Bay, Dunmanus Bay, Bantry Bay, Kenmare River, Valentia, The Shannon Estuary, Galway Bay including Cashla, Kilkieran Bay and Greatman's Bay, Beirtreach Bui & Roundstone Bay, Clifden Bay, Ballinakill and Streamstown Bays, Killary Hbr, Clew Bay, Blacksod Bay, Inner Donegal Bay, north west Donegal and L. Swilly. The majority of landings originate in Cork and Galway. The migration of adults is limited to small scale offshore movements in late autumn. The larvae are pelagic and distributed in open water but settle into shallow sub-tidal habitats in later summer. The fishery is mainly for 1 year old shrimp and to a lesser extent 0+ shrimp in late autumn. Each area, listed above, may hold discrete stocks although the degree to which this is true depends on how larvae are retained in each system. Variability in recruitment and biomass, as reflected in the performance of the fishery and annual landings, can vary independently across these areas supporting the idea of separate stocks. For management purposes each area can be treated separately.

4.4 *Galway Bay*

4.4.1 The distribution of the fishery

The fishery is concentrated in the inner Bay and especially on the north and east shores (Figure 1). In 2010 and 2011 the fishery began on September 1st although the season legally opens on August 1st. The delay in the start of the fishery is by local agreement to allow recruiting shrimp to increase in weight during August. The majority of vessels grade the catch using 8-10mm graders on board the vessels and discard rejected shrimp alive. Discard survival is thought to be high although bird predation / scavenging occurs.

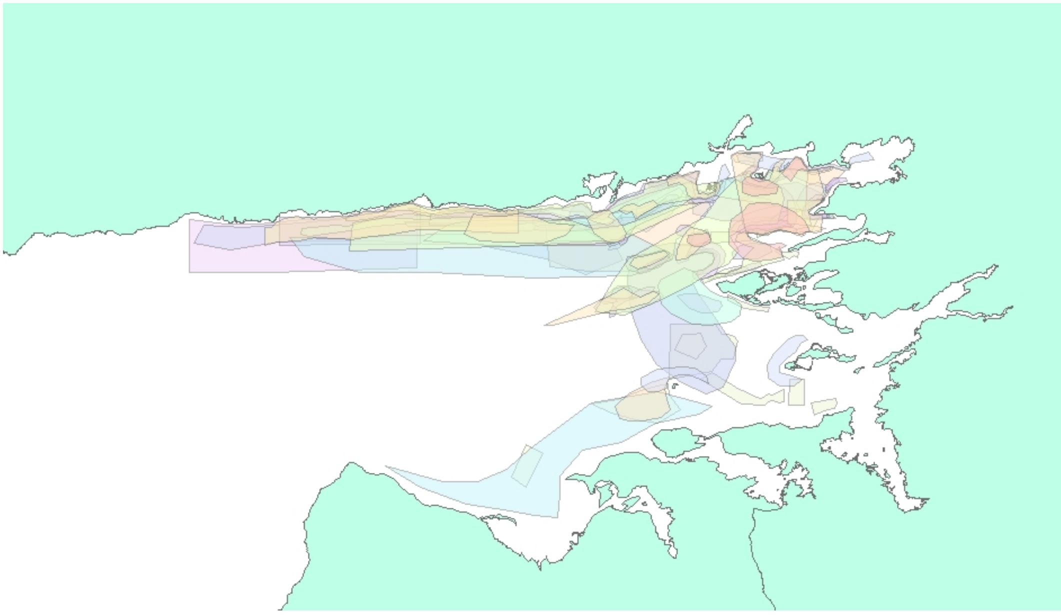


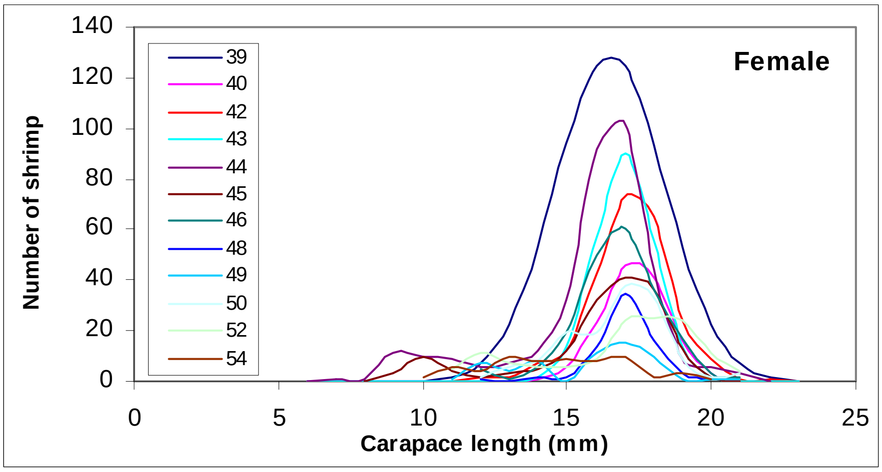
Figure 1. Distribution of shrimp fishing in Galway Bay showing the approximate fishing areas of each vessel superimposed in semi-transparent layers. Effort is concentrated on the north east corner and the northern shore.

4.4.2 Size and age composition of the catch 2011

The catch was dominated by 1+ male and 1+ female shrimp. Young of the year shrimp recruited to the fishery towards the end of November. This recruitment signal was weak (

Figure 2,

Table 3). No consistent changes in size at age were observed between October and December and size at age had declined by early January 2012. This may be due to selective grading, removal of larger shrimp and live discarding of smaller shrimp during the season. Females 1+ as a proportion of the catch declined during the season and the proportion of males 1+ increased as did the proportion of 0+ shrimp.



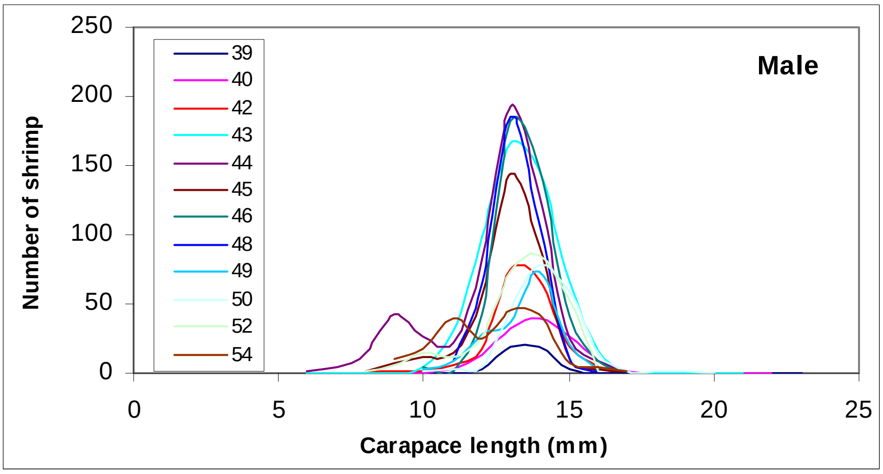


Figure 2. Size composition of male and female shrimp in Galway Bay by week from October1st . The dominant modes are 1+ year old shrimp.

Table 3. Age composition of the shrimp catch by week in Galway Bay during Autumn 2011 (CL=Carapace Length).

Week	Female age				Male age				Proportion at age			
	0+		1+		0+		1+		Female		Male	
	Size (CL)	**N**	**Size**	**N**	**Size**	**N**	**Size**	**N**	**0+**	**1+**	**0+**	**1+**
39			17	606			14	44	0.00	0.93	0.00	0.07
40			17.8	135			14.3	126	0.00	0.52	0.00	0.48
42	12.5	1	17.7	237	10.5	7	14	187	0.00	0.55	0.02	0.43
43			17.4	247			13.7	518	0.00	0.32	0.00	0.68
44	10.99	43	17.1	300	9.6	93	13.7	457	0.05	0.34	0.10	0.51
45	10.81	19	17.4	143	10.3	28	13.7	315	0.04	0.28	0.06	0.62
46	12.2	9	17.4	194	10.4	2	14	427	0.01	0.31	0.00	0.68
48	12.5	1	17.5	72		0	13.6	379	0.00	0.16	0.00	0.84

49	13.4	19	17.6	39	10.4	1	13.9	172	0.08	0.17	0.00	0.74
50	14.3	19	17.6	119	11	1	14.7	205	0.06	0.35	0.00	0.60
52	13.5	29	18.4	102	11	43	14.2	230	0.07	0.25	0.11	0.57
54	12.6	19	16.2	44	11.1	71	13.9	122	0.07	0.17	0.28	0.48

4.4.3 Fishery performance in 2011

Following the very poor season in 2010 there was some recovery in 2011 especially in the northern part of the Bay. Approximately 17 tonnes of shrimp were landed between September 2011 and early January 2012.

Nominal catch rate and catch rate standardised to number of 1+ females did not decline during the season or in relation to cumulative landings (Figure 3). Nominal catch rate increased in November and was stable until early January along the north shore although fishing effort migrated westwards to maintain this catch. In shallow waters in the north east of the Bay and in the south of the Bay catch rates fell rapidly in late December. The stability in the catch for vessels which moved gear into deeper waters and the collapse in catch rates in shallow water indicate that a migration of the stock into deeper water occurred probably in response to storms in mid and late December. As depletion in the catch rate was not observed the exploitation rate could not be estimated.

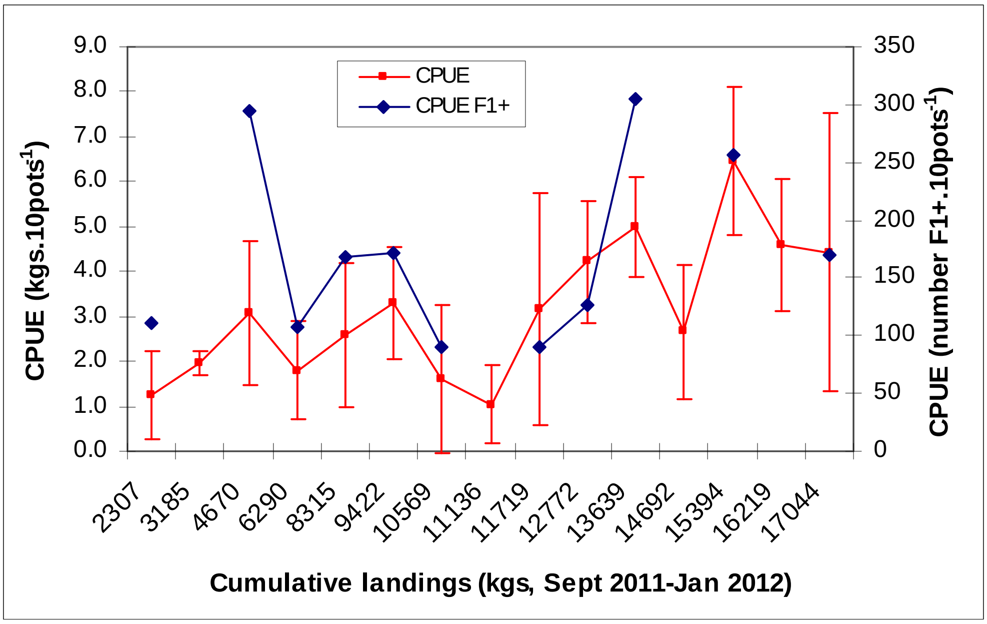


Figure 3. Relationship between nominal catch rates, catch rates of 1+ female shrimp and cumulative landings in the Galway Bay shrimp fishery in 2011-2012. Cumulative landings are estimated from buyer's records and the proportion of catch going to one buyer for which records were not available.

5 Crayfish (*Palinurus elephas*)

5.1 Management recommendations

The current minimum landing size of 110mm should be retained unless effort control can be introduced. A reduction in the minimum landing size from 110mm to 95mm, in parallel with a maximum landing size of 120mm, could protect the stock to the same degree as the current minimum size of 110mm, if fishing mortality was low. However, at high levels of fishing mortality the conservation effect of the maximum size would be minimal.

Measures to reduce loss of crayfish to scavenging crustaceans, to reduce loss of other potentially valuable commercial species, to protect uncommon or rare species of skates and rays and to minimise capture of designated species such as grey seals and cetaceans should be developed. These by-catch issues are more important in some areas than in others.

5.2 Issues relevant to the assessment and management of the crayfish fishery

- The fishery is currently managed using a minimum landing size of 110mm carapace length. In addition there are two areas, west of Kerry and Galway, closed to tangle nets.
- The minimum size is well above the size at maturity.
- The fishery, prior to the 1970s was a pot fishery but today it is entirely a tangle net fishery. Historically, catch rates were much higher than they are currently.
- Catch rates in tangle nets are extremely low in some areas but support viable fisheries in others. High market price, low gear costs and long gear soak times make the fishery viable at very low catch rates.
- Discard mortality is over 20% in some areas due to scavenging by crustaceans and net damage.
- By-catch of spider crabs, edible crab, lobster, skates and rays and other fish is significant, but mortality and loss (up to 80% in some areas) of this catch due to crustacean scavenging, seal depredation and damage caused by long gear soak times greatly reduces the value of the by-catch in some areas.
- Species such as grey seal and cetaceans are at risk from capture in tangle nets.
- Data provision, in particular on fishing effort and its geographic distribution, is poor.
- No recovery of the stock is likely given the current management regime, especially, as fishing effort increases quickly in response to any signals of increased recruitment.
- Management measures are currently under review (http://www.agriculture.gov.ie/press/pressreleases/2011/may/title,55617,en.html).

5.3 Management Units

Crayfish occur on reef habitats along the west and south coasts of Ireland. The larval life is up to 9 months long and there is obviously a significant capacity for large scale dispersal of larvae during this time. Juveniles settle onto reefs and are relatively sedentary. Adults may undertake significant migrations although tagging results are variable. Stock structure is likely to be determined by oceanographic conditions and its effects on larval dispersal. There is insufficient information available on which to identify management units at this time.

5.4 The Fishery

5.4.1 Evolution of the fishery

The crayfish fishery in Ireland evolved gradually from the 1930s initially as a by-catch in the lobster fishery. From the 1930s to the 1970s there was a gradual increase in the use of French barrel pots which increasingly targeted crayfish as well as lobster (Figure 4). With the exception of the early 1940s there was a corresponding increase in landings during this period peaking during the early 1950s-1970s at an approximate average of 150 tonne per annum. Periodic targeted fisheries by '50 footers' occurred on the south west coast in the 1950s and off the south east coast in the early 1960s. Tangle nets were introduced into the fishery, quickly replacing top entrance pots, in the early 1970s. Landings declined between 1974 and 1988. Over 200 tonnes were landed in 1989 but landings continued to decline thereafter and up to the present day. Landings are currently about 20-30 tonnes per annum.

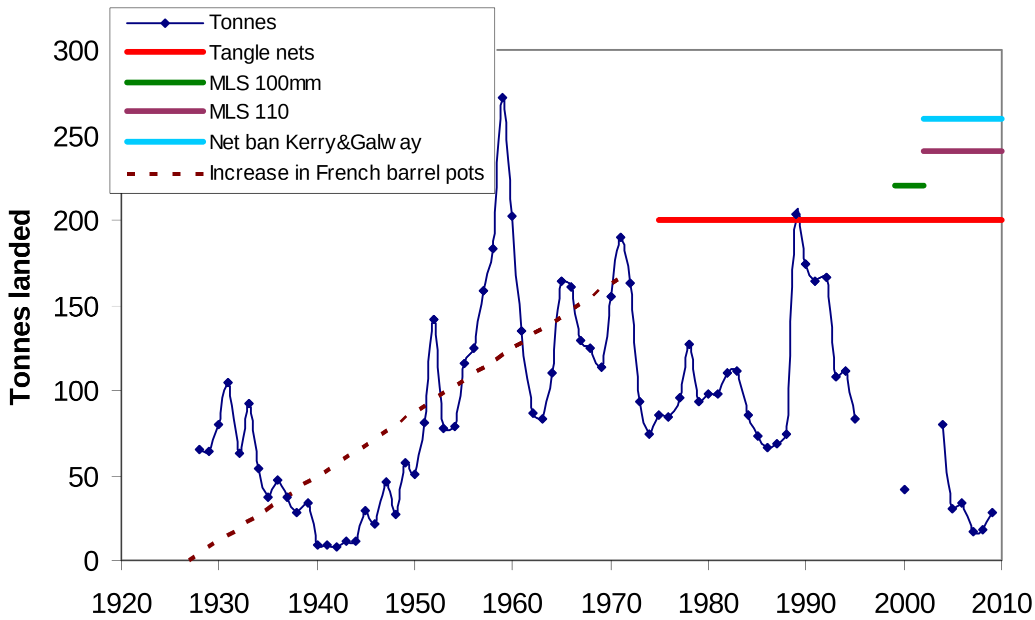


Figure 4. Evolution of landings, fishing patterns and management measures for crayfish in Ireland between 1920s and 2010.

5.4.2 Trends in biomass

There are no estimates of stock biomass. Data on catch per unit effort could provide indices of biomass but these data are sparse and of variable quality. In Ireland and in Europe generally landings and catch rates have declined and probably very significantly since the 1970s although there are few hard data to show this decline

There are few reliable catch rate data for pots prior to the introduction of tangle netting in the 1970s. Anecdotal and some quantitative information in catch rates in pots in particular, indicate the following

- Gibson (1972) documents a 50:50 ratio of landings of crawfish and lobster off the Wexford coast in the

1960s. Today, landings of crayfish into Wexford are zero.

- In 1972 quantitative catch rate data from top entrance pots fished off the south west coast show a catch rate of 7.9±8.0 crawfish per 100 trap hauls.
- In 1999 average monthly catch rates in top entrance pots varied from 0.1 to 2.89 per 100 trap hauls in April and August respectively.
- Comparison of the quantitative catch rate data from top entrance pots in 1972 and 1999, from the south west coast, indicates a 7 fold decline.
- In the 1999 survey in the south west the ratio of lobsters to crayfish was 7.6:1.
- In 1970 crawfish landings totalled 150 tonnes or approximately 130,000 fish given a mean weight of 1.2kgs (equivalent to mean sizes for the period given in Molloy 1970). Simplistically, the number of pot hauls required to take this volume of landings at 1999 catch rates is 11.7million.
- Where previously crayfish were commercially fished with pots such a fishery is no longer viable because of low catch rates.

5.4.3 Size composition

5.4.3.1 Data availability

No national regular sampling programme for crayfish was or is in place in Ireland. A comprehensive sampling of the landings was undertaken in 1967-1968 (O'Riordan unpublished). Large samples (n=18,606) were taken in 1967-68 in particular and as such these data represent an accurate baseline profile of the size composition of the landings prior to the introduction of tangle nets in the early 1970s. As there were no management measures in place these data probably also reflect the size composition of the catch of crayfish in top entrance pots at this time. Mercer (1973) studied crayfish on the west coast for a number of years in the early 1970s and reports size frequency data in the landings although sample sizes are small by comparison to the 1967 programme. Mercer's samples are mainly/solely from tangle nets. Due to concerns about the fishery in the early 1990s Maddock *et al.* (1996) undertook a national sampling programme. This project also provided large samples from the landings from tangle nets but the resolution of the measurements is low at 10mm rather than 5mm in the earlier data. The mesh size of tangle nets in 1996 was smaller compared to those in 1973 when Mercer's samples were taken. The Marine Institute sampled crayfish catch in tangle nets in Roaring Water Bay in 2010 and 2011. Sampling was also undertaken in Kerry in 1972 and 2007 and in Donegal in 2006 but sample sizes are small in these latter cases.

5.4.3.2 Trends in size composition

- In 1967 the modal size of male and female crayfish was 110-120mm. Approximately 40% were below 110mm. Above 140mm, males were more common (10%) than females (3%).
- In 1973 the modal size of females was 120-130mm and 30% were below 110mm. The modal size of males was 160-170mm and only 20% were less than 110mm (Mercer 1973).
- In 1996 the modal size of male and female crayfish was 90-110mm and 110-120mm respectively. Approximately 81% of male and 41% of female crayfish were below 110mm.

In 2010-2011 in Roaring Water Bay modal size of male crayfish was between

90-110mm and modal size of female crayfish was between 100-120mm. Approximately 70% of males and 55% of females were below 110mm (Table 4,

- Figure 5).

The female size distributions are more stable than those of males and in fact the differences between 1967 and 2010 female data are relatively minor. There is little pattern in the male data; the 1973 and 1996 size compositions are 'mirror images' with contrasting modal sizes of 160-170mm 90-100mm respectively. The 1973 data are local, may not reflect the size composition of the national stock at the time and could be considered to be an outlying sample.

Table 4. Percentage of crayfish below 110mm in the crayfish fishery,1967 and 2011.

	% below 110mm		Fishing method	Catch or landings
Year	Male	Female		
1967	40	40	Top entrance pots	Landings (representative of catch)
1973	20	30	Tangle nets	Landings (representative of catch)
1996	81	41	Tangle nets	Landings (representative of catch)
2011	70	55	Tangle nets	Catch

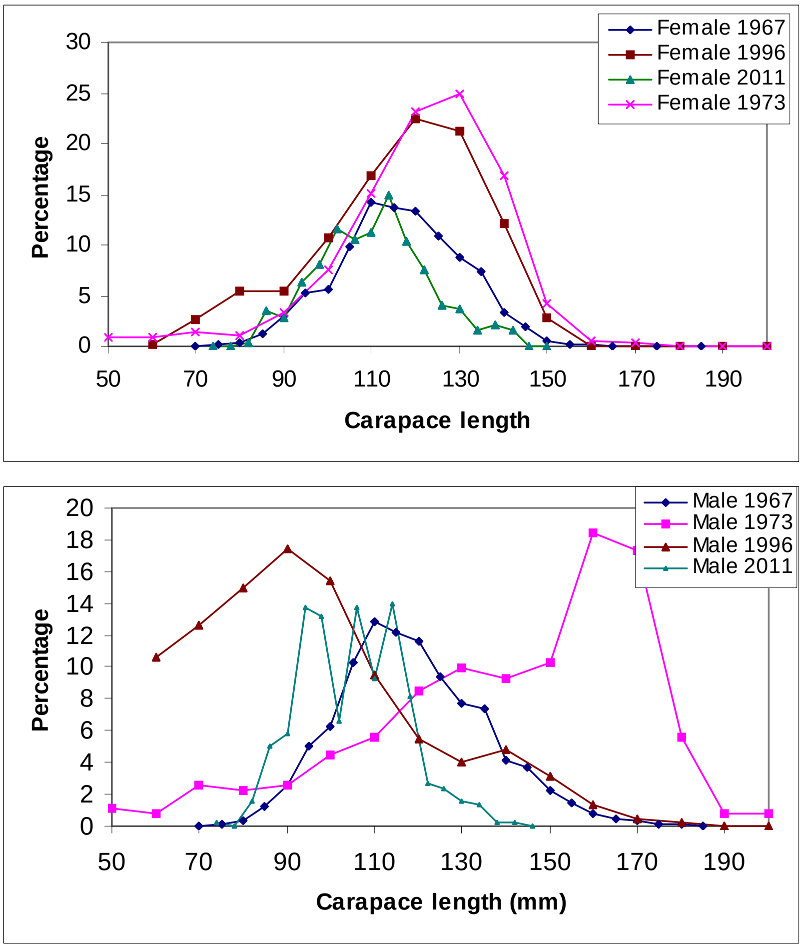


Figure 5. Size composition of the crayfish catch in the Irish fishery, 1967-2011.

5.4.4 Evaluation of changes in size limits on egg production per recruit (EPR)

Stock biomass and recruitment appear to be low and, given current management arrangements, size limits are the only means of controlling fishing mortality. Evaluation of the effectiveness of various size limits on egg production per recruit (EPR) is presented here and in the context of an industry request in 2011 for a reduction in the minimum size. Terms of reference of a Ministerial review in 2011 also indicated that any change in regulation should not erode the conservation effect provided by the 110mm size limit (http://www.agriculture.gov.ie/press/pressreleases/2011/may/title,55617,en.html).
A more complete account of the management review is in Tully (2011).

5.4.4.1 Methods and uncertainties

An individual based model (Bell 2007) was used to assess effects of changes in size limits on egg production. Biological and fishery parameters used in the model are presented in Tully (2011). There is substantial uncertainty in almost all of the parameters. Nevertheless comparison of relative changes in EPR, rather than the absolute EPR, at different multipliers of current fishing mortality rates can be used to evaluate the effects of different size limits and to reflect aspects of the fishing process such as different levels of discard mortality of undersized fish.

Various size limits of 110mm (current position), 100mm and 95mm with or without a maximum size at 115mm, 120mm and 130mm are evaluated under different conditions of catchability and at 0% or 18% discard rates. A discard mortality rate of 18% was observed in the Tralee Bay fishery in 2007 (Power *et al.* 2008) and a 0% discard mortality rate was observed in Roaring Water Bay in 2011.

5.4.4.2 Assessment

Estimates of fishing mortality, obtained from length cohort analysis (not shown), are surprisingly low given the decline in catch and presumably biomass. Simulations of EPR at two levels of catchability are therefore provided. At catchability of 0.0027 changes in minimum size from 110mm to 100mm or 95mm reduces EPR by 27% and 42%, respectively. Maximum size limits between 115-130mm are ineffective conservation measures at high fishing mortality and would lead to reductions in EPR of 24-40% if MLS was reduced to 95mm. If catchability was 0.0014 reducing the minimum size to 95mm and introducing a maximum size at 120mm would afford equivalent protection to EPR as the current 110mm minimum size (Table 5, Figure 6, Figure 7).

Table 5. % changes in EPR (relative to current position of EPR at 110mm) at various minimum (MLS) and maximum sizes (MaxLS) and different conditions of catchability and discard mortality rate. Blue shading is the current position (assuming high F and 2 levels of discard mortality).

MLS	MaxLS	Catchability	Discard mortality rate	% change in EPR
95	120	0.0014	0	0
110	None	0.0027	0	0
95	None	0.0027	0	-42
100	None	0.0027	0	-27
95	130	0.0027	0	-40
95	120	0.0027	0	-36
95	115	0.0027	0	-24
110	None	0.0027	0.18	0
95	None	0.0027	0.18	-33
100	None	0.0027	0.18	-18
95	130	0.0027	0.18	-29
95	120	0.0027	0.18	-28
95	115	0.0027	0.18	-25

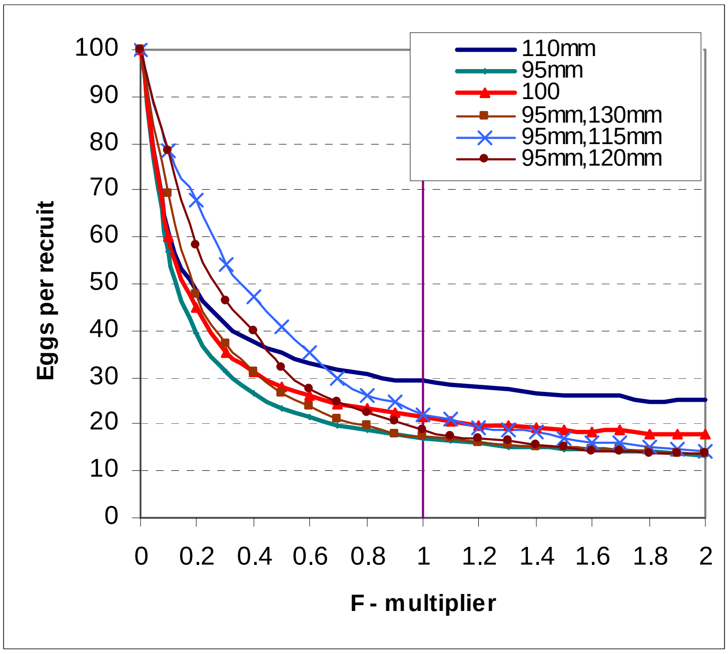


Figure 6. Egg production per recruit estimates for crayfish under different combinations of minimum and maximum size limits and assuming catchability is 0.0027, for fully selected size classes, and discard mortality rate is zero.

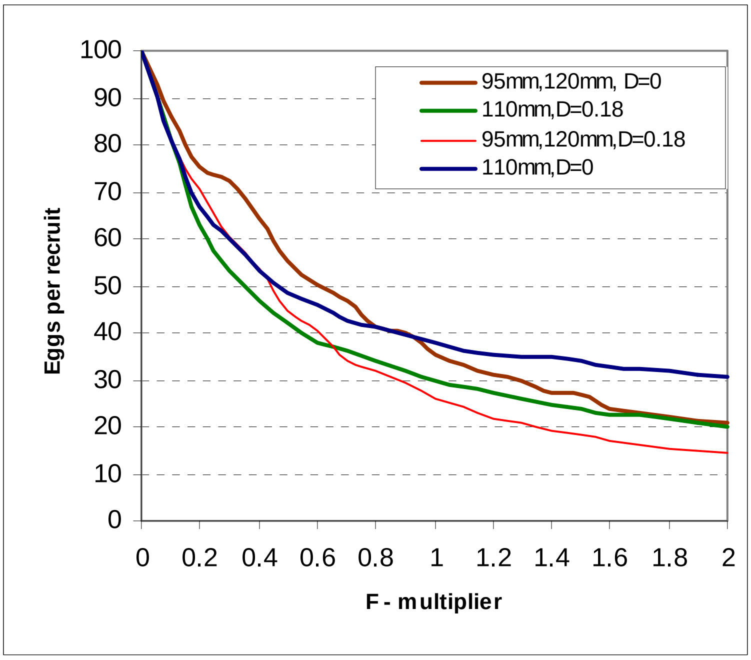


Figure 7. Egg production per recruit estimates for crayfish under different combinations of minimum and maximum size limits and assuming catchability is 0.0014, for fully selected size classes, and discard mortality is 0 or 18%.

5.4.5 By-catch in the crayfish tangle net fishery

The tangle net fishery for crayfish involves the capture of commercial and non-commercial species as by-catch. By-catch varies regionally. Power *et al.* (2008) report on by-catch in the tangle net fishery in north Kerry and to a lesser extent in west Cork and Mayo. Limited observations on by-catch were obtained in Roaring Water Bay in 2010 and 2011 by the Marine Institute.

5.4.5.1 North Kerry

The composition of the by-catch was estimated from 29 nautical miles of tangle nets hauled over 13 days in north Kerry in 2007 (Table 6).

Nine species of fish, 7 species of elasmobranch, 4 crustacean species and bottle nosed dolphin occurred in the by-catch. Numerically the by-catch was dominated by spider crab.

By-catch mortality was high

- 89% of vertebrate by-catch was dead when the nets are hauled.
- 85% of by-catch mortality of fish was caused by scavenging by peracarid crustaceans (skinners). Seal depredation causes 2% mortality of fish.
- Up to 50% of undersized brown crab may suffer post discard mortality due to loss of limbs during extraction from the nets.
- Spider crab mortality was highly variable but was at least 25%.
- Crayfish mortality was between 18-26% and was highest in crayfish under the MLS of 110mm.
- Lobster by catch was 3% (estimate based on low numbers).

Table 6. By-catch data for the north Kerry tangle net fishery for crayfish, from 29nm of nets hauled (from Power *et al*. 2008).

Species	Alive	Seals	Skinners'	Spoiled	% mortality	Total individuals
Lobster					3% (low numbers)	
Spider crab					25% (not quantified)	
Brown crab					50% (undersized)	
Crayfish					18-26	
Blonde ray	1					1
Bull Huss			3			3
Cod	2		2			4
Common skate	2		6			8
Conger eel			2			2
Dolphin			2			2
Gadoid			44			44
Ling			4			4
Mackerel	1					1
Monkfish	5	6	35	2		48
Pollack	8		11			19
Spotted Dogfish	1		17			18
Spur dog	2		9			11
Sunfish			1			1
Thornback ray	4		83			87
Turbot	2		3			5
Grand Total	**28**	**6**	**221**	**2**		**257**
Percentage	**10.89**	**2.33**	**85.99**	**0.78**		

5.4.5.2 West Cork

By-catch composition in the west cork tangle net fishery in 2011, compiled by the Marine Institute, for 11 fishing days involved 10 species but predominantly brown crab and spider crab (Table 7). Mortality of brown crab and spider crab in the nets was negligible. One specimen of Thornback Ray was recorded. No other elasmobranch, seal, cetacean or seabird by-catch was recorded. Discard mortality of crayfish was not observed and no scavenging activity by skinners was evident.

Table 7. Composition and condition of by-catch in the crayfish tangle net fishery in Roaring Water Bay in autumn 2011.

Species	Condition	05/07/2011	14/07/2011	19/07/2011	25/07/2011	27/07/2011	28/07/2011	03/08/2011	11/08/2011	18/08/2011	26/08/2011	31/08/2011	Grand Total
Brown crab legal	Live	3	3	3	3	2	3	3	4	3	3	3	33
Brown crab undersized	Live					3	1					2	6
Bullhuss	Dead											1	1
Cray undersized	Dead										1		1
Dogfish	Dead											1	1
Dogfish	Live											2	2
Lobster legal	Live	1	1			1	1	1	2				7
Lobster undersized	Live											1	1
Mackerel	Dead											1	1
Monkfish legal	Dead	1										2	3
Monkfish legal	Live						1	1					2
Pollack	Dead											1	1
Spider crab legal	Live	3	2	3	1	2	2	3	4	3	3	1	27
Spider crab legal	Dead					1							1
Spider crab undersized	Live				1		1						2
Spider crab undersized	Dead					1							1
Thornback Ray	Dead											1	1
Turbot	Dead											2	2
Grand Total		8	6	6	5	10	9	8	10	6	7	18	**93**

5.4.5.3 Assessment of by-catch data

Bottle nosed Dolphin

This species is designated under the Habitats Directive and is the subject of a species national action plan (DEHLG 2009). There is a resident population, of approximately 130 individuals (Foley *et al.* 2010), of bottle-nosed dolphins in the Shannon Estuary close to the north Kerry tangle net fishery and there are other, genetically distinct inshore populations on the Galway-Mayo coasts, which show some site fidelity to these areas (Mirimin *et al.* 2010). Anthropogenic induced mortality on small 'local' populations, using the method of Wade (1978), should probably be zero or close to zero for long term stability of these 'local' populations. Any risk of by-catch of individuals from such small populations, in set net fisheries, therefore, may be incompatible with the conservation objectives for this designated species. In large open populations some by-catch mortality could be tolerated.

Skates and rays

Bullhuss (*Scyliorhinus stellaris),* Thornback ray (Raja clavata), Blonde Ray (*Raja brachyura*), *Scyliorhinus canicula (Less spotted dogfish) and Dipturus batis (Common skate)* were observed in the Kerry tangle net fishery. In addition *Raja undulata (Undulate Ray), Squatina squatina (Angel shark) and Raja alba (White skate),* are at risk of capture in the tangle net fishery. Angel Shark and White skate are rare in NW Europe. The only population of Undulate ray in Ireland is centered in the Tralee Bay area. Sting ray have also been observed in this area.

ICES advises that Angel Shark and White Skate should be returned alive and that there should be no directed fishery for Undulate Ray and measures to reduce by-catch of this species should be implemented (ICES 2010, Table 8).

The Tralee Bay area is a 'biodiversity hot-spot' for skates and rays (Marine Dimensions 2009) and in particular for rare species such as Angel Shark, White Skate and Undulate Ray.

Other pressures on these elasmobranch species in the Tralee area include the rod and line recreational sea angling fishery although such fishing methods would allow for these species to be released alive.

Table 8. Stock status and ICES advice on Rays and Skates found in Irish waters and which are vulnerable to tangle net fishing gears.

Species	**Sub-area of VII**	**Status of stock**	**ICES Advice**	**Note**
Common skate complex	All	Depleted	No targeted fishery	Zero TAC
Raja clavata (Thornback Ray)	All	Stable/increasing, Uncertain in VIIe	Status quo catch	
Raja montagui (Spotted ray)	VIIa,f,g,e	Stable/increasing, Uncertain in VIIe	Status quo catch	
Raja brachyura (Blonde Ray)	VIIa,e,f	Uncertain	No advice	
Raja undulata (Undulate ray)	VIIj,d,e	Uncertain, locally common	No targeted fishery	**Measures to reduce by-catch to be implemented in VIIj**
Scyliorhinus canicula (lesser spotted dogfish)	All	Increasing	Status quo catch	
Scyliorhinus stellaris (dog fish, bullhuss)	All	Locally common, increasing in VIIa	No advice	
Squatina squatina (angel shark)	All	Rare and near extirpated	**Prohibited**	
Rostroraja alba (white skate)	All	Rare and near extirpated	**Prohibited**	

6 Surf clam (*Spisula solida*)

6.1 Management recommendations

Landings from surf clam beds should be limited to avoid over exploitation especially given that recruitment to the stocks is sporadic and the fishery relies on individual strong year classes.

6.2 Issues relevant to the assessment and management of the surf clam fishery

- The fishery is currently regulated using a minimum legal size of 25mm shell length (longest dimension) effected through on board mechanical grading. Voluntary, TAC agreements have been in place in recent years.
- 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.

6.3 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.

6.4 Waterford estuary

6.4.1 Biomass 2010 and 2011

The biomass estimate for surf clams in the Waterford estuary in 2011 was 175±34 tonnes. This assumes a dredge efficiency of 100%, which is unlikely, and therefore the actual biomass is probably underestimated. The estimate for 2010 was 132 tonnes (
Figure 8, Table 9).

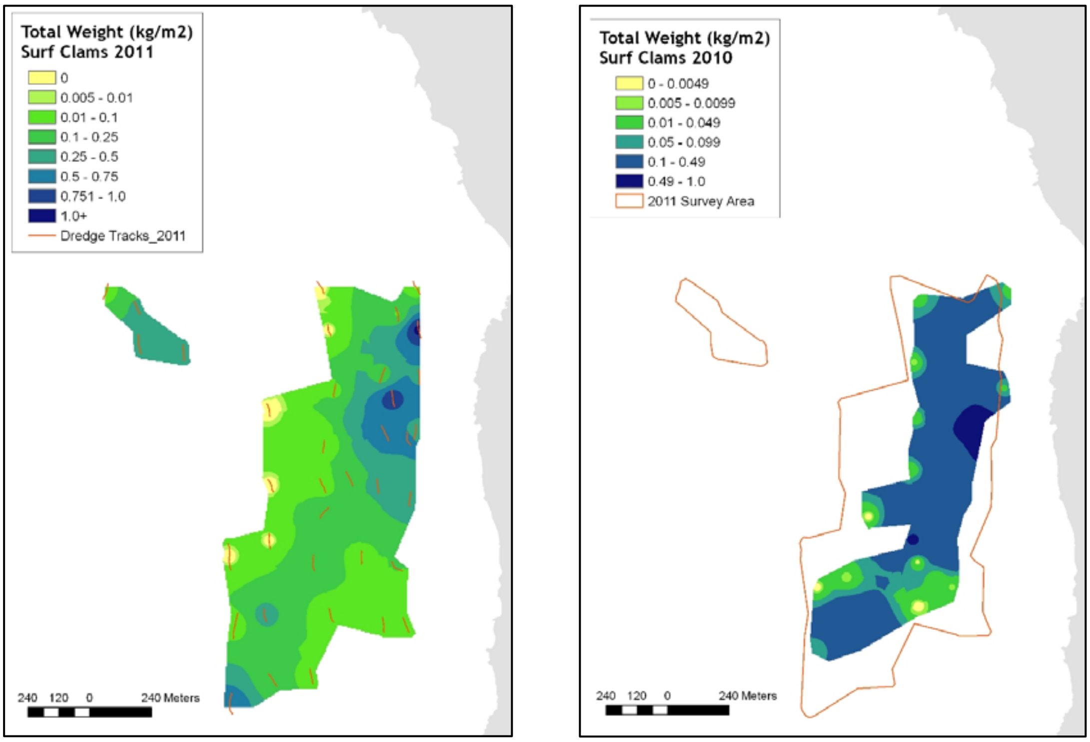


Figure 8. Distribution of surf clam biomass in the Waterford estuary in 2010 and 2011.

Table 9. Distribution of surf clam biomass in Waterford estuary in 2011.

			Biomass.m^{-2}			Biomass (kgs)	
Contours (kgs.m^{-2})	**Area (m^2)**	**N**	**Mean**	**SD**	**95% CL**	**Total**	**95% CL**
0	14,638	6	0.00	0.00	0.00	0	0
0.005-0.01	13,275	1	0.01	-	-	107	-
0.01-0.1	312,260	11	0.05	0.02	0.01	15,475	4,445
0.1-0.25	330,405	6	0.16	0.05	0.04	54,196	14,849
0.25-0.5	158,066	8	0.34	0.08	0.06	53,757	8,999
0.5-0.75	64,684	3	0.66	0.08	0.09	42,397	5,720
0.75-1.0	8,578	1	0.92	-	-	7,882	-
1.0+	763	1	1.06	-	-	811	-
Total	**902,668**	**37**				**175 tonnes**	**34**

6.4.2 Size and age composition 2009-2011

Grab sampling in 2009 and dredge sampling in 2010 failed to detect any recruitment to the stock but 1+ clams were recorded during the 2010 and 2011 dredge surveys. Age composition data suggests that recruitment to the clam bed may be irregular with strong and weak year classes (Table 10, Figure 9). The age composition of the landings was dominated by 3 year old clams in 2009, 4+ clams in 2010 and 4+ and 5+ clams in 2011 suggesting that the current biomass and fishery is supported by a strong 2006 year class. This progression was not visible in the size composition data although 2009 clams were smaller than those in 2010.

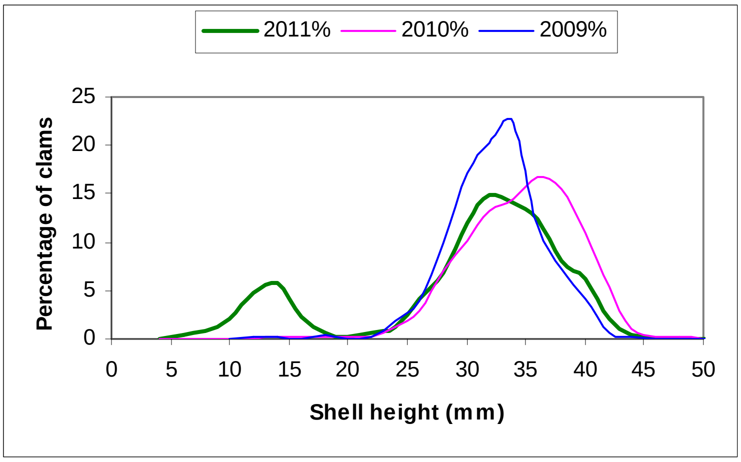


Figure 9. Shell height of surf clams in 2009, 2010 and 2011 in the Waterford estuary clam bed.

Table 10. Percentage age composition of surf clams in the Waterford estuary in 2010 and 2011.

	2009		2010		2011	
Age	**N**	**%**	**N**	**%**	**N**	**%**
0	0	0	0	0	106	5.2
1	0	0	16	5.2	227	11
2	19	16.7	13	4.2	58	2.8
3	82	**71.9**	22	7.2	240	11.7
4	11	9.6	223	**72.9**	812	**39.5**
5	1	0.9	22	7.2	487	**23.7**
6	1	0.9	6	2	89	4.3
7	0	0	3	1	24	1.2
8	0	0	0	0	10	0.5
9	0	0	1	0.3	2	0.1
	114		**306**		**2,055**	

6.4.3 Landings and catch rates 2009-2011

Total annual landings in the period 2009-2011 were 39, 162 and 73 tonnes respectively. Although a 150 tonne TAC was agreed in 2011 with a maximum of 20 tonnes per boat for the first part of the season. Low participation lead to poor uptake of the TAC. Harvest rules in this fishery included a minimum size of 25mm shell height, a maximum landing of 2 tonnes per boat per day and an agreement to close the fishery when catch rates declined to 50% of their start of season value. No significant in season catch rate depletion was observed in any year (Figure 10). However, if the cumulative catch for the 3 years is taken in sequence there are indications of an overall decline in catch rate, from approximately 450 kgs.hr^{-1} at the start of the 2009 season, to approximately 325 kgs.hr^{-1} at the end of the 2011 season. Taking the years 2009-2011 in sequence is justified given the apparent absence of recruitment into the stock in 2009 and 2010 and the observed progression in the age composition of the landings during 2009-2011.

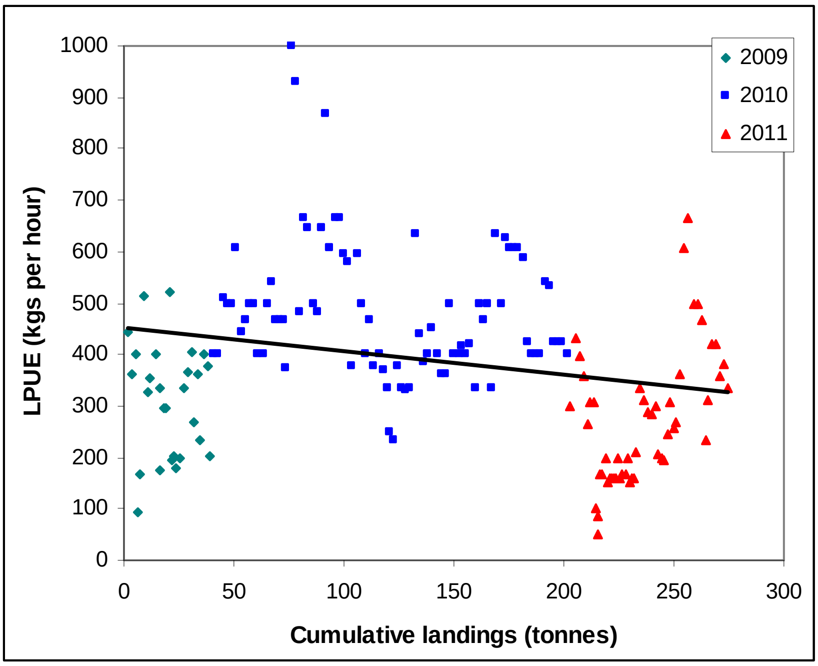


Figure 10. Landing rates (kgs.hr^{-1}) in the Waterford Estuary surf clam fishery in relation to cumulative landings in 2009, 2010 and 2011.

7 Cockle (*Cerastoderma edule*)

7.1 Management recommendations

The management regime for cockles in the period 2007-2010 used a suite of measures which effectively limited exploitation rates and protected juvenile cockles.

The fishery measures as outlined in the various Dundalk Bay cockle management plans should be continued. In addition mortality of discarded cockles and non-target bivalves should be estimated and mitigation measures put in place if required. 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.

7.2 Issues relevant to the assessment and management of the cockle fishery

- There are a number of cockle beds on the Irish coast. In recent years the main fisheries have occurred in Dundalk Bay and Waterford Estuary.
- The Dundalk fishery is currently managed by a minimum landing size (17mm shell width), seasonal closures, TAC (33% of biomass) and minimum biomass and catch rate opening and closing conditions, respectively.
- 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 variable.
- 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.
- Data provision by industry is mandatory, well complied with and provides in season data on catch and effort for implementation of TAC and catch rate harvest control rules.
- Dundalk Bay and Waterford estuary are Natura 2000 sites. Cockle is both a characterising species of designated habitats within these sites and also an important food source for overwintering bird populations. Management of cockle fisheries must and is taking 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 in 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 two have supported commercial dredge fisheries in recent years; Dundalk Bay and Waterford estuary. Commercial stocks also occur in Tramore Bay, Co. Waterford and in Clew Bay Co. Mayo but these stocks have not been commercially fished in recent years.

7.4 Dundalk Bay

7.4.1 Biomass 2007- 2011

Biomass estimates from annual surveys in 2007-2011 are not strictly comparable because of differences in the time of year in which surveys were undertaken (Table 11). 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.

The 2007 biomass of 2,277 tonnes was distributed mostly in cockles greater than 18mm shell width. The fishery in 2007 removed approximately 900 tonnes (including an approximate estimate for hand gatherers) of cockles over 22mm. 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 18mm 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.

Although the stock was not fished in 2008 the biomass was lower in 2009 than in 2008 and lower again in 2010 although the total landing from the 2009 fishery was only 108 tonnes. Natural mortality appears to have been very high during the winter 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.

Table 11. Annual biomass, TAC and landings of cockles in Dundalk Bay 2007-2011.

Year	Survey Month	Biomass		TAC (tonnes)	Landings	
		Mean	95% CL		Vessels	Hand gatherers
2007	March	2,277	172	950	668	Unknown
2008	August	3,588	1,905	0	0	0
2009	June	2,158	721	719	108	0.28
2010	May	814	314	0	0	0
2011	May	1,530	94	510	325	0.25

7.4.2 Biomass in 2011

Pre and post fishery surveys, in May and December respectively, were completed in 2011. The fishery was open from Sept 15th to Nov 30th.

Pre-fishery (May)

In May the total biomass, ± 95% confidence limits, of cockles in the sampling domain (26.6 km^2) was 1,531±94 tonnes (Table 12). Approximately 1400 tonnes of this biomass occurred in densities of over $5m^{-2}$. The biomass of cockles over 18mm shell width was 789±60 tonnes. Approximately 300 tonnes occurred in densities over $5m^{-2}$. The biomass of cockles over 22mm shell width was 426±38 tonnes. Forty eight tonnes occurred in densities over $5m^{-2}$.

Post-fishery (Dec)
In December the total biomass, ± 95% confidence limits, of cockles in the sampling domain (10.9 km^2) was 853±112 tonnes (Table 13). Approximately 775 tonnes of this biomass occurred in densities of over 5m^{-2}. Note that the area surveyed in December was less than in May. The biomass of cockles over 18mm shell width, in the survey area, was 559±180 tonnes. Approximately 444 tonnes occurred in densities over 5m^{-2}. The biomass of cockles over 22mm shell width was 146±36 tonnes. The majority of this biomass was distributed at densities less than 5.0m^{-2} (119 tonnes) with 27.2 tonnes of it occurring in densities greater than 5m^{-2}.

If the December biomass estimate is raised to the area surveyed in May the total biomass in December was 2,217 tonnes which is higher than the pre-fishery biomass in May of 1,531 tonnes. Although the fishery removed 325 tonnes most of the biomass, including the major proportion of 0+ cockles was unavailable to the fishery because of the operational MLS of 22mm. Cockles aged 0+ increased in weight 9 fold between May and December.

Table 12. Distribution of cockle biomass in Dundalk Bay in May 2011.

Contours	Area (sqm)		Density				Biomass (gm^{-2})		Biomass (tonnes)	
	Area	% of area	N	Mean	S.d.	CL	Mean	CL	Mean	CL
0	396,634	1.49	46	0.00	0.00	0.00	0.00	0.00	0.0	0.0
0.25-1.9	3,046,409	11.45	55	0.83	0.52	0.14	7.28	1.25	22.2	3.8
2.0-4.9	4,538,990	17.05	49	3.37	0.97	0.28	22.82	2.18	103.6	9.9
5.0-9.9	6,097,564	22.91	69	7.30	1.46	0.35	47.20	2.46	287.8	15.0
10.0-24.9	9,640,578	36.22	100	15.91	4.22	0.85	83.13	4.54	801.4	43.8
25.0-49.9	2,840,878	10.67	40	34.06	6.83	2.17	109.39	7.30	310.8	20.7
>50	56,619	0.21	2	66.88	1.94	2.76	94.27	11.10	5.3	0.6
Total	**26,617,673**		**361**						**1,531**	**94**

Table 13. Distribution of cockle biomass in Dundalk Bay in December 2011. The survey extent was 2.6 times lower than in May 2011.

Contours	Area (sqm)		Density				Biomass (gm^{-2})		Biomass (tonnes)	
	Area	% of area	N	Mean	S.d.	CL	Mean	CL	Mean	CL
0	118,199	1.08	9	0.00	0.00	0.00	0.00	0.00	0.0	0.0
0.25-1.9	1,255,367	11.48	21	0.58	0.35	0.14	8.56	2.06	10.7	2.6
2.0-4.9	1,919,263	17.55	26	3.14	0.67	0.25	35.05	3.00	67.3	5.7
5.0-9.9	3,588,436	32.81	29	6.92	1.49	0.55	66.56	5.36	238.8	19.2
10.0-24.9	3,755,494	34.33	30	14.47	3.22	2.64	118.62	21.72	445.5	81.6
25+	301,674	2.76	6	31.38	3.02	0.55	301.60	9.07	91.0	2.7
Total	**10,938,432**		**121**						**853**	**112**

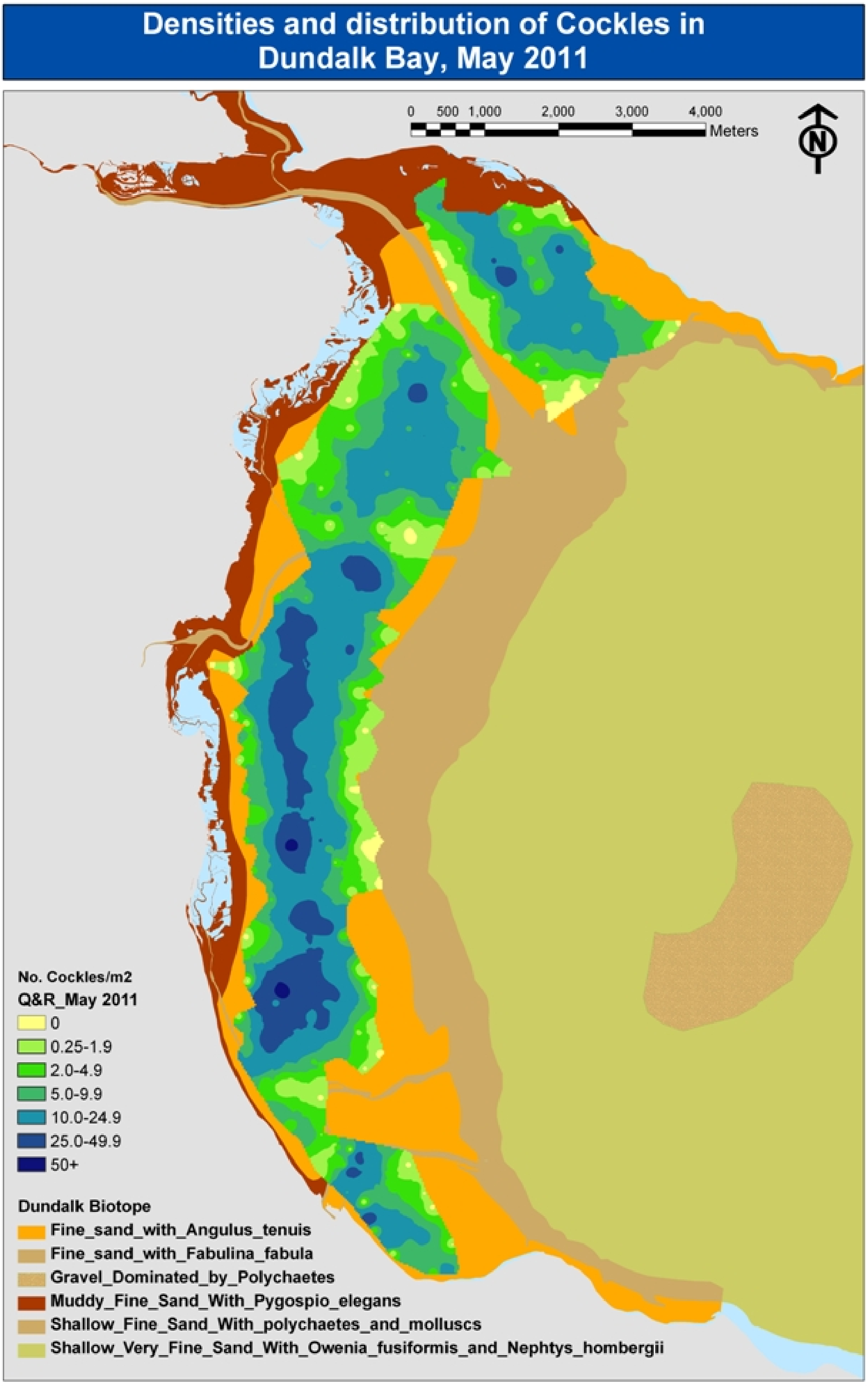


Figure 11a. Distribution of cockles in Dundalk Bay in May 2011. The surveyed area was 26 km^2. Underlying biotopes are indicated (NPWS 2011).

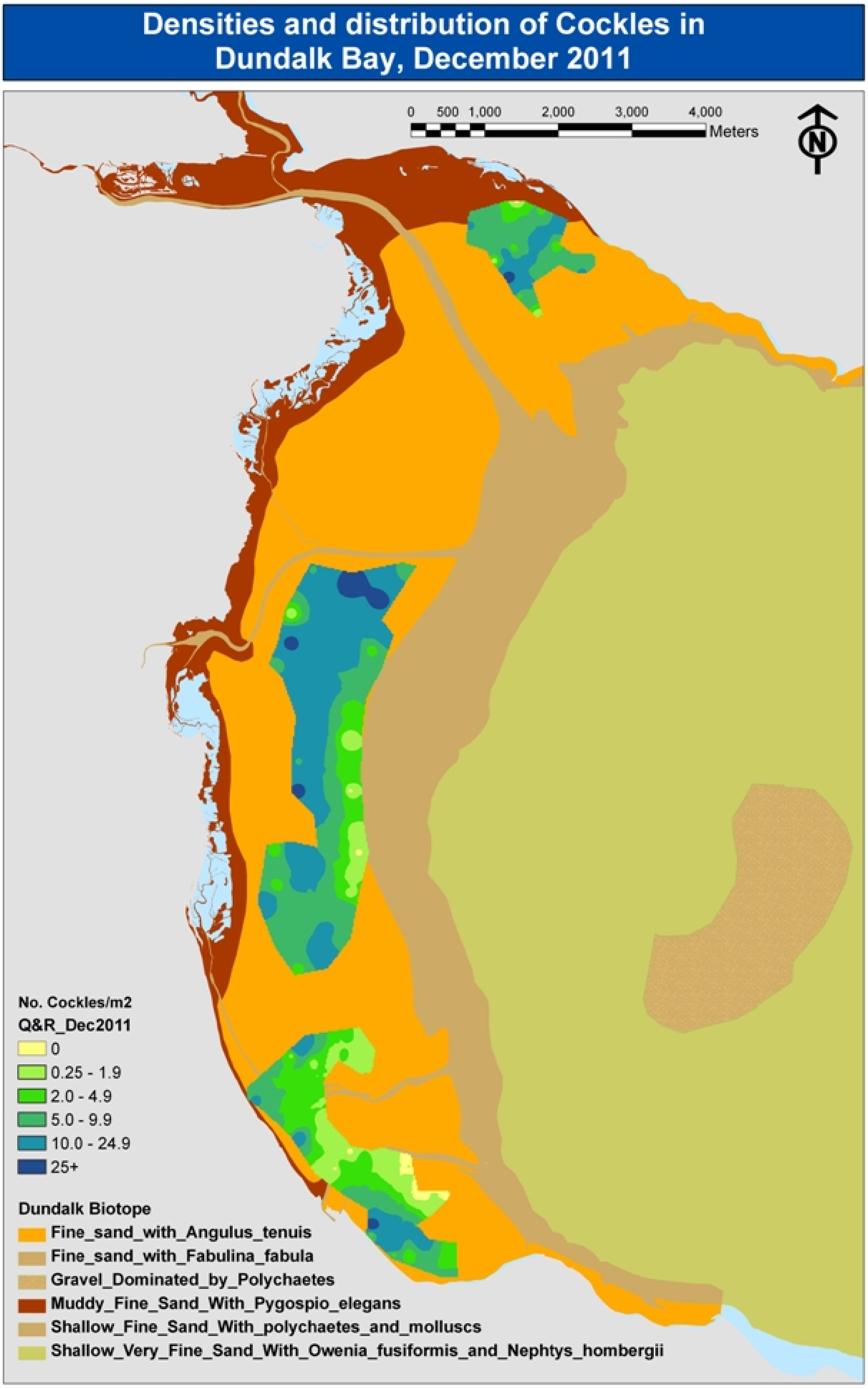


Figure 11b. Distribution of cockles in Dundalk Bay in December 2011. The surveyed area was 10km^2. Underlying biotopes are indicated (NPWS 2011).

7.4.3 Size and age in 2011

In May 0+ (62%) and 1+ (18%) age classes predominated (Figure 12). These averaged 8.2mm and 17.2mm shell width, respectively. A proportion of the second component in the size distribution also contained 2-3 year old cockles at average sizes of 21.8mm and 27.5mm. A small number of cockles over age 3 were present.

In December the size distribution was dominated by the 0+ (66%) age class which had a modal shell width of approximately 17.1mm. Cockles aged 1-3 years were 21.4, 25.2 and 29.4mm, respectively. Age classes were not visible in the size distribution data in December.

Seasonal increase in weight was 5-6g for age classes 0-3 (Table 14).

Table 14. Size at age data for Dundalk cockles in May and December 2011.

Age	Shell width			Weight		
	May	Dec	Difference (mm)	May	Dec	Difference (g)
0+	8.20	17.13	8.93	0.62	5.69	5.07
1+	17.22	21.41	4.19	5.78	11.13	5.35
2+	21.88	25.27	3.38	11.88	18.33	6.45
3+	27.50	29.40	1.90	23.65	28.91	5.27

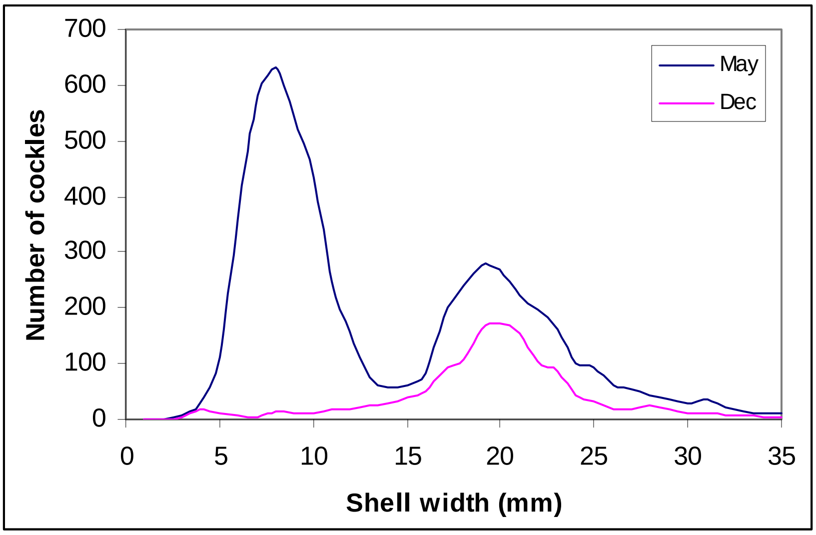


Figure 12. Shell width distribution of cockles in Dundalk Bay in May and Dec 2011. The operational minimum landing size is 22mm.

7.4.4 Landings and catch rates in 2011

Harvest control rules and regulations for the Dundalk fishery in 2011 included

- A TAC of 33% of the total biomass.
- An operational minimum landing size of 22mm shell width and mandatory use of graders on fishing vessels.
- Closure in the event of landings per effort declining below $250kg.boat^{-1}.day^{-1}$.
- Specified opening and closing dates which vary annually.

Landings totalled 325 tonnes and 63% of the TAC in 2011. Take up of the TAC was limited by the length of the season but also because the biomass was dispersed at low densities which decreased the efficiency of the vessels.

Landings per boat per day, estimated from logbook data and averaged over each week during the fishing season, declined from 0.68 tonnes on week 39 to 0.34 tonnes on week 49. The catch rate trigger for closure of the fishery, described in the management plan, was 0.25 tonnes (Table 15).

Landing rates per hour (standardising daily landing rates for variation in daily fishing time), showed an initial landing rate of 0.166 tonnes.hr^{-1} for suction dredges and 0.118 tonnes.hr^{-1} for non-suction. This increased in the second week and subsequently declined linearly as landings accumulated. Catch rates in the first week are lower because vessel operators are adjusting the gear configuration and solving technical problems that may arise during the initial days.

Extrapolating the regression of catch rate on cumulative landings (Leslie depletion) indicates a pre-fishery biomass of cockles over 22mm of 667 tonnes compared to 426 tonnes estimated in the May survey (Figure 13). The differences may largely be accounted for by the doubling in weight of 1+ cockles between May and September and growth of 2+ and 3+ cockles during that period.

Table 15. Catch rate and landings (tonnes) by week and gear type in the 2011 Dundalk Bay cockle fishery. *Total landing was 325 tonnes. Date of landing is unknown for 3 tonnes.

Week	Landings	Cumulative landings	Land per boat per day	Landings per fishing hour			
				All gears (mean)	All gears (S.d.)	Suction (mean)	Non-suction (mean)
38	18.22	18	0.47	0.15	0.074	0.17	0.12
39	15.79	34	0.68	0.19	0.071	0.20	0.17
40	77.30	111	0.57	0.17	0.076	0.19	0.14
41	67.66	179	0.52	0.15	0.067	0.17	0.14
42	51.00	230	0.48	0.14	0.049	0.15	0.12
43	23.27	253	0.44	0.13	0.051	0.14	0.12
44	15.81	269	0.39	0.12	0.048	0.13	0.10
45	17.91	287	0.39	0.12	0.044	0.13	0.10
46	7.63	295	0.36	0.11	0.038	0.12	0.10
48	20.58	315	0.38	0.11	0.036	0.11	0.10
49	6.81	**322***	0.34	0.11	0.044	0.11	0.07

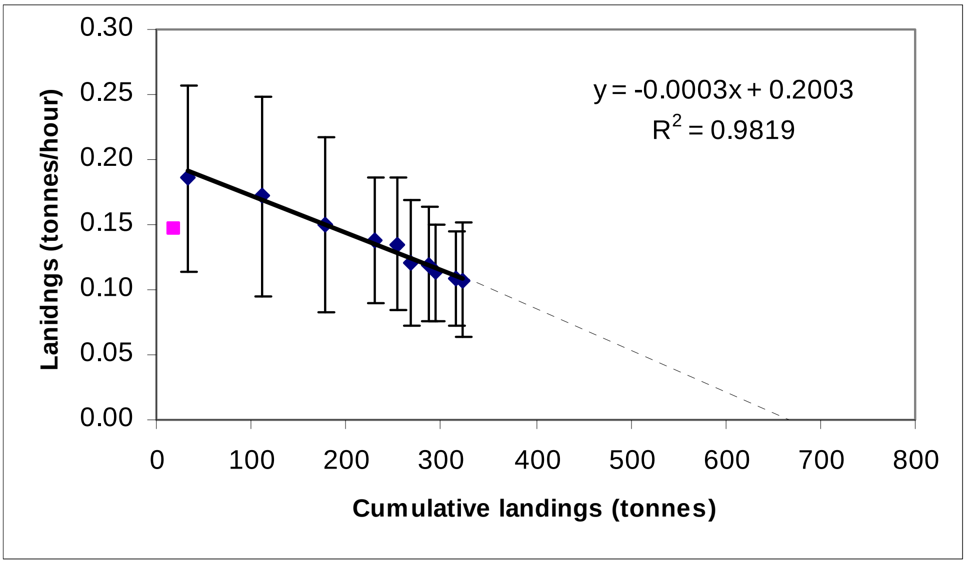


Figure 13. Average landing rate per week ($tonnes.hr^{-1}$) plotted against cumulative landings in the 2011 Dundalk Bay cockle fishery. The first data point is excluded from the regression. Error bars are standard deviations. Extrapolation to zero catch rates provides a pre-fishery estimate of biomass of cockles over 22mm of 667 tonnes.

7.5 Waterford Estuary and Tramore Bay

7.5.1 Biomass 2007-2011

Survey data for the period 2007-2011 provided fishery independent estimates of biomass (Table 16). Biomass was similar in Woodstown in 2007 and 2008 but lower in Passage East in 2008 than in 2007. No commercial cockles were found in either area during the 2009 or 2010 surveys. In 2011 236 tonnes of cockles were present in Woodstown. These were under the minimum size and no fishery occurred.

A large biomass of 2,375 tonnes was present in Tramore in 2007. No surveys were completed in Tramore in 2008-2010. Biomass in 2011 was 1,495 tonnes.

In 2007 TACs, representing 33% of the biomass, were set for Passage East and Woodstown. The TAC for Tramore was set to zero as no management plan was agreed. In 2008 TACs were zero in all areas as no appropriate assessment of the impact of the fishery on the conservation objectives of the Special Areas of Conservation in which the fisheries take place had been undertaken. The commercial biomass in Woodstown and Passage East was very low in 2009, 2010 and 2011 and there was no fishery. Although a commercial biomass was found in Tramore in 2011 no fishery plan was developed and the TAC was therefore set to zero.

Table 16. Annual biomass estimates and TACs for cockle beds in Waterford Estuary and Tramore.

Year	Area	Biomass	95% C.I.	TAC	Landings
2007	Woodstown	367	24	121.11	154
	Passage East	276	24	91.08	
	Tramore	2,375	230	0	0
2008	Woodstown	388	221	0	0
	Passage East	96	60	0	0
	Tramore	-	-	0	0
2009	Woodstown	0	0	0	0
	Passage East	0	0	0	0
	Tramore	-	-	0	0
2010	Woodstown	0	0	0	0
	Passage East	0	0	0	0
	Tramore	-	-	0	0
2011	Woodstown	236	43	0	0
	Passage East	0	0	0	0
	Tramore	1,495	184	0	0

7.5.2 Biomass Woodstown and Passage East 2011

A total biomass of 236±46 tonnes was present in Woodstown in June 2011 (Figure 14, Table 17). Biomass was close to zero in Passage East.

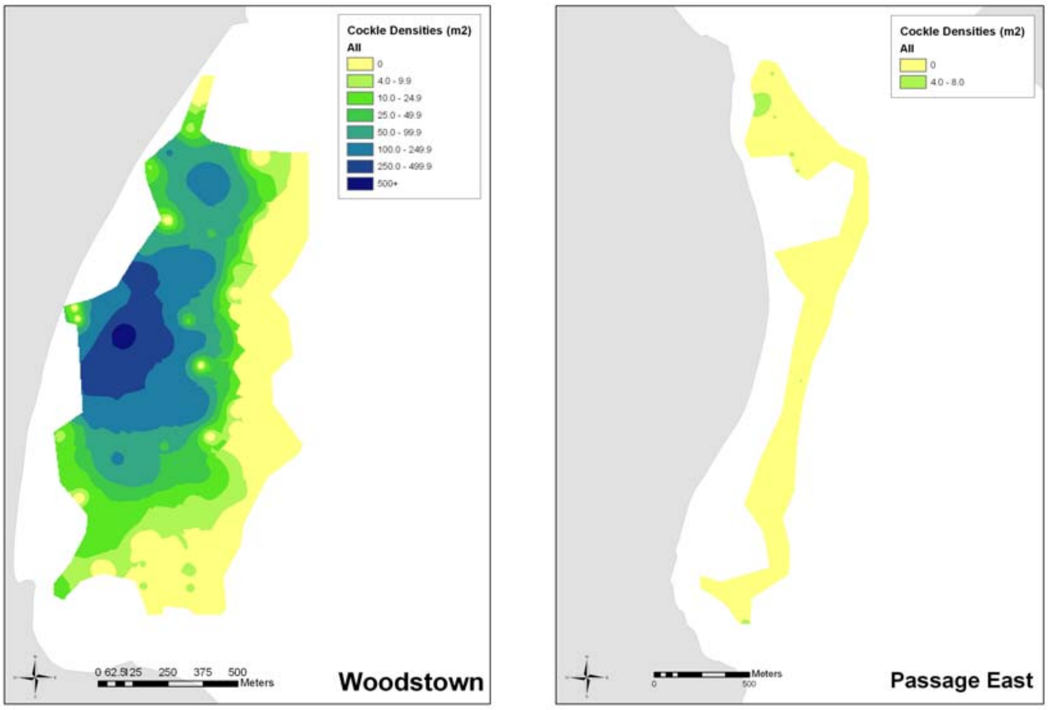


Figure 14. Distribution of biomass of cockles at Woodstown and Passage east in Waterford Estuary in June 2011.

Table 17. Distribution of cockle biomass at Woodstown in June 2011 (CL=Confidence Limits).

Contours	Area	% of Area	Density				Biomass (gm^{-2})		Biomass (tonnes)	
			N	Mean	S.d.	CL	Mean	CL	Mean	CL
0	313,452	28.65	32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.0 - 9.9	103,774	9.49	11	5.45	2.02	1.22	25.32	5.92	2.63	0.61
10.0 - 24.9	132,292	12.09	7	18.67	4.84	3.68	75.20	15.13	9.95	2.00
25 - 49.9	107,298	9.81	3	44.00	6.93	8.04	143.33	26.89	15.38	2.89
50.0 - 99.9	171,828	15.71	3	62.67	9.24	10.72	213.33	37.24	36.66	6.40
100.0 - 249.9	170,235	15.56	10	170.00	46.45	29.52	433.52	75.47	73.80	12.85
250.0 - 499.9	88,557	8.10	3	414.67	70.47	81.77	999.20	198.41	88.49	17.57
500+	6,485	0.59	1	628.00	0.00	0.00	1,396.40	49.59	9.06	0.32
Total	**1,093,921**		**70**				**Total**		**236**	**43**

7.5.3 Size and age composition Woodstown and Passage East 2011

Approximately 91% of cockles in Woodstown in June 2011 were 1+ years having settled in 2010 (Figure 15). There was no evidence of any settlement in 2011. The age composition was truncated to 3 cohorts (Table 18).

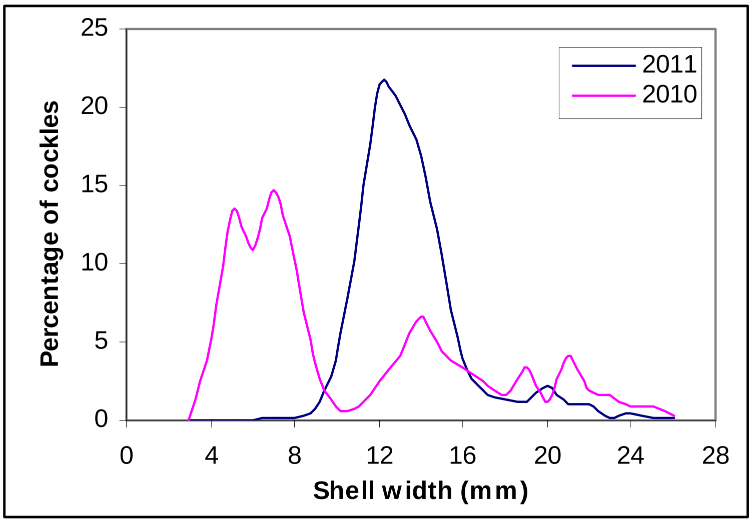


Figure 15. Size distribution of cockles in Woodstown in 2010 and 2011.

Table 18. Size at age of cockles at Woodstown in 2011.

Age	N	%	Shell width	
			Mean	S.d.
1	929	91.0	12.5	1.7
2	80	7.8	18.3	2.8
3	12	1.2	21.6	1.9

7.5.4 Biomass Tramore 2011

A total biomass of 1,495±184 tonnes of cockles were recorded at Tramore back strand in June 2011. Just over 1,000 tonnes of this was over the minimum legal size of 17mm. Densities exceeded 300 cockles.m^{-2} in some areas (Figure 16). Areas containing high densities were similar in 2007 (previous survey) and 2011.

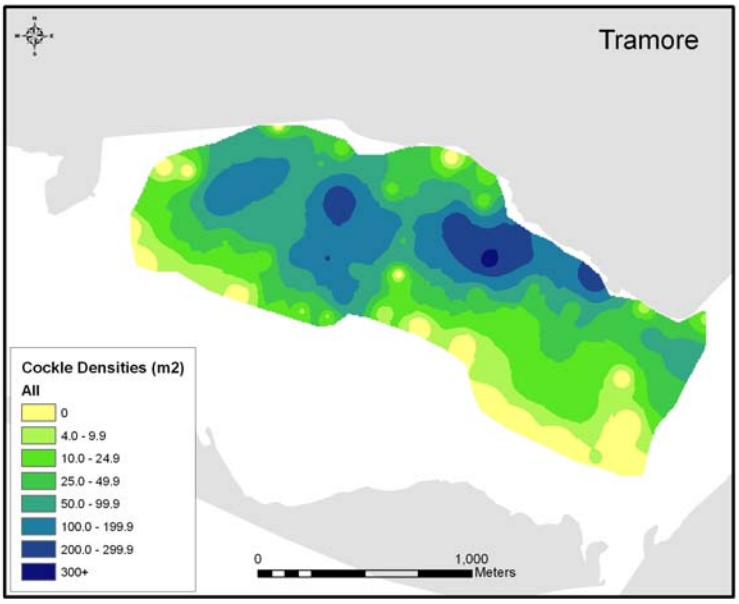


Figure 16. Distribution of cockle biomass in Tramore back strand in June 2011.

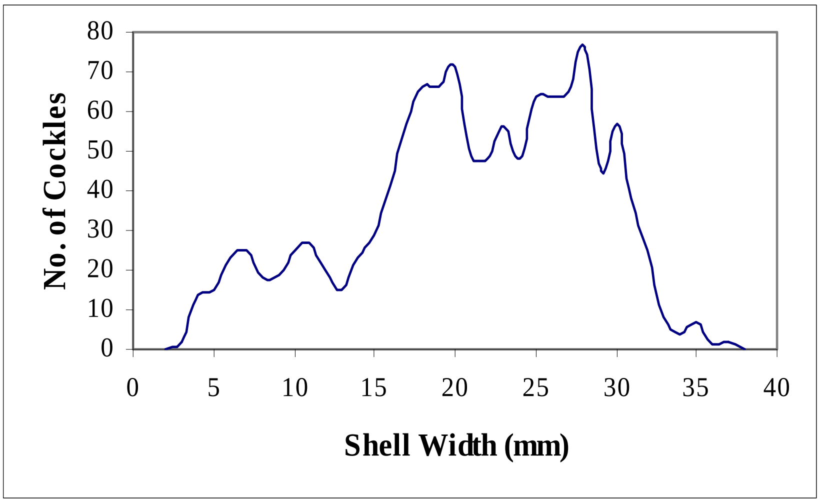
Table 19. Distribution of cockle biomass in Tramore back strand in June 2011.

Contours	Area m²	% of Area	Density				Biomass (gm⁻²)		Biomass (tonnes)	
			N	Mean	S.d.	CL	Mean	CL	Mean	CL
0	182,382	8.52	16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.0-9.9	217,097	10.14	9	5.78	2.11	1.41	119.27	30.91	25.89	6.71
10.0-24.9	400,337	18.70	12	15.33	3.75	2.18	210.56	31.79	84.29	12.72
25.0-49.9	403,254	18.84	13	38.15	7.94	4.42	358.90	44.82	144.73	18.07
50.0-99.9	453,901	21.21	10	70.00	15.58	9.90	618.89	91.23	280.91	41.41
100.0-199.9	362,279	16.93	10	146.80	23.33	14.83	1,905.16	194.32	690.20	70.40
200.0-299.9	115,663	5.40	6	262.67	42.76	35.09	2,168.24	292.56	250.79	33.84
300+	5,496	0.26	1	344.00	0.00	0.00	3,381.20	91.52	18.58	0.50
Total	**2,140,409**		**77**				**Total**		**1,495**	**184**

7.5.5 Size and age composition Tramore 2011

At least 9 age classes were present in the Tramore cockle stock in 2011 (

Figure 17, Figure 18). However, the 0+ and 1+ year class strength (2010 and 2011 settlement) appears to have been poor relative to 2009 settlement. This stock has not been commercially fished to any significant extent for a number of years.



Age	0+	1+	2+	3+	4+	5+	6+	7+	8+	9+
Size	6.1	11.7	16.3	20.1	21.8	23.9	26.2	27.8	29.2	30.4
N	99	92	165	257	169	85	80	156	72	10
%	8.4	7.8	13.9	21.7	14.3	7.2	6.8	13.2	6.1	0.8

Figure 17. Size and age composition of cockles at Tramore back strand in June 2011.

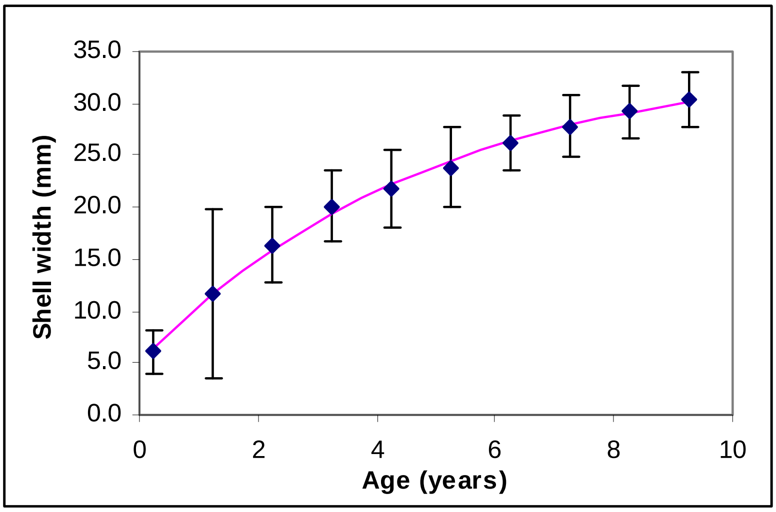


Figure 18. Size at age data and fitted vonBertalanffy growth model for cockles in Tramore back strand in 2011. Parameters for the growth model, and scaling the first year class to 0.25years, are k = 0.21, L∞ = 34.2 and t_o = -0.7.

8 Oyster (*Ostrea edulis*)

8.1 Management recommendations

Stock biomass is generally low in all areas, except Tralee Bay, and management measures to restore recruitment and re-build spawning stocks are necessary. Various threats to native oyster stocks exist including naturalisation of Pacific oyster (*Crassostrea gigas*), *Bonamia* infection, poor habitat conditions for settlement, low spawning stocks. A control programme for Pacific oyster in Lough Swilly may be required although the continuation of the commercial dredge fishery for Pacific oyster in the Lough may go some way to controlling its expansion.

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. Oyster management plans also need to consider measures that comply with the conservation objectives for designated habitats.

8.2 Issues relevant to the assessment and management 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 and seems to have failed in recent years in a number of locations. Larval production and settlement is conditional on density of spawning stock, high summer temperatures and the availability of suitable substrate.
- The fishery is managed primarily by a minimum landing size of 76-78mm. 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 arrangements in most cases management objectives and management measures are not sufficiently developed. In L. Swilly all management authority rests with the overseeing government department.
- 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 co-operatives operate seasonal fisheries and may also limit TAC. 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.

8.3 Summary

In 2011 oyster biomass was estimated from dredge surveys, in Fenit (inner Tralee Bay), Galway Bay and Lough Swilly (Table 20).

Table 20. Biomass and landings data for native oyster fisheries in 3 areas surveyed in 2011.

Oyster stock	Biomass (tonnes) 2011	Survey date	Landings (tonnes) 2011
Inner Tralee Bay (Fenit)	1,278	September	100
Lough Swilly	124	November	Unknown
Galway Bay	35	April	15
Total	**1,437**		

8.4 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.

8.5 Survey methods

Oyster beds were surveyed 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.

Predetermined survey grids were used where the distribution of the oyster beds were well known. In other cases the local knowledge of the Skipper of the survey vessel was 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, converted for dredge efficiency, were subsequently 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.

8.6 *Lough Swilly*

8.6.1 Distribution and abundance of native oyster

Surveys in Lough Swilly were completed in March and November 2011. The March survey was restricted to areas not licenced for aquaculture while the November survey covered all known oyster beds in the area (Figure 19).

Densities of native oyster (*E. edulis*) in March, corrected for 35% dredge efficiency, ranged from 0-5.8m^{-2} (Table 21). The total number and biomass of native oysters in the survey area were estimated to be 1.58 million oysters and 40±16 tonnes, respectively.

Densities in November 2011, also corrected for dredge efficiency, ranged from 0-3.8 oysters m^{-2}. The total number and biomass of native oysters in the survey area were estimated to be 5.13 million oysters and 124.39±0.24 tonnes, respectively (Table 22).

Table 21. Density and biomass of native oyster in Lough Swilly in March 2011.

Density	Area 1000m2	N	Mean density m²	95% CL density	Number of oysters	Biomass (gms m²)	95% CL Biomass m²	Total Biomass tonnes	CL Biomass (Tonnes)
0	26.8	3	0.00	0.00	0	0.00	0.00	0.00	0.00
0.01 - 0.1	232.9	11	0.05	0.02	11,943	1.28	0.03	0.30	0.01
0.1 - 0.5	329.4	25	0.25	0.13	81,437	6.19	0.78	2.04	0.26
0.5 - 1.0	383.4	11	0.72	0.14	274,551	17.92	2.53	6.87	0.97
1.0 - 2.5	426.8	21	1.55	0.45	660,299	38.72	17.35	16.53	7.40
2.5 - 5.0	147.7	8	3.35	0.59	494,949	83.85	49.85	12.39	7.36
5.0+	10.1	1	5.89	0.00	59,939	147.40	0.00	1.50	0.00
Total	**1,557**	**80**			**1,583,119**			**40**	**16**

Table 22. Density and biomass of native oyster in Lough Swilly in November 2011.

Density (DE=35.5%)	Area 1000m²	N	Mean density m²	95% CL density	Number of oysters	Biomass (gms m²)	95% CL Biomass m²	Total Biomass (tonnes)	CL Biomass (Tonnes)
0	2,778	82	0.00	0.000	0	0.00	0	0.00	0.00
0.01-0.099	2,934	37	0.05	0.008	143,089	1.58	0.63	4.62	1.84
0.1-0.49	3,751	28	0.28	0.043	1,034,435	8.14	2.96	30.55	11.10
0.5-0.99	2,297	22	0.71	0.058	1,636,755	18.21	7.47	41.84	17.17
1.0-1.99	968	13	1.46	0.170	1,417,171	31.70	18.46	30.71	17.88
2.0-2.99	296	7	2.45	0.269	726,968	42.20	28.95	12.52	8.59
3.0+	45	1	3.88	0.000	176,076	91.26	0.00	4.14	0.00
Total	**13,072**	**190**			**5,134,493**			**124.39**	**56.59**

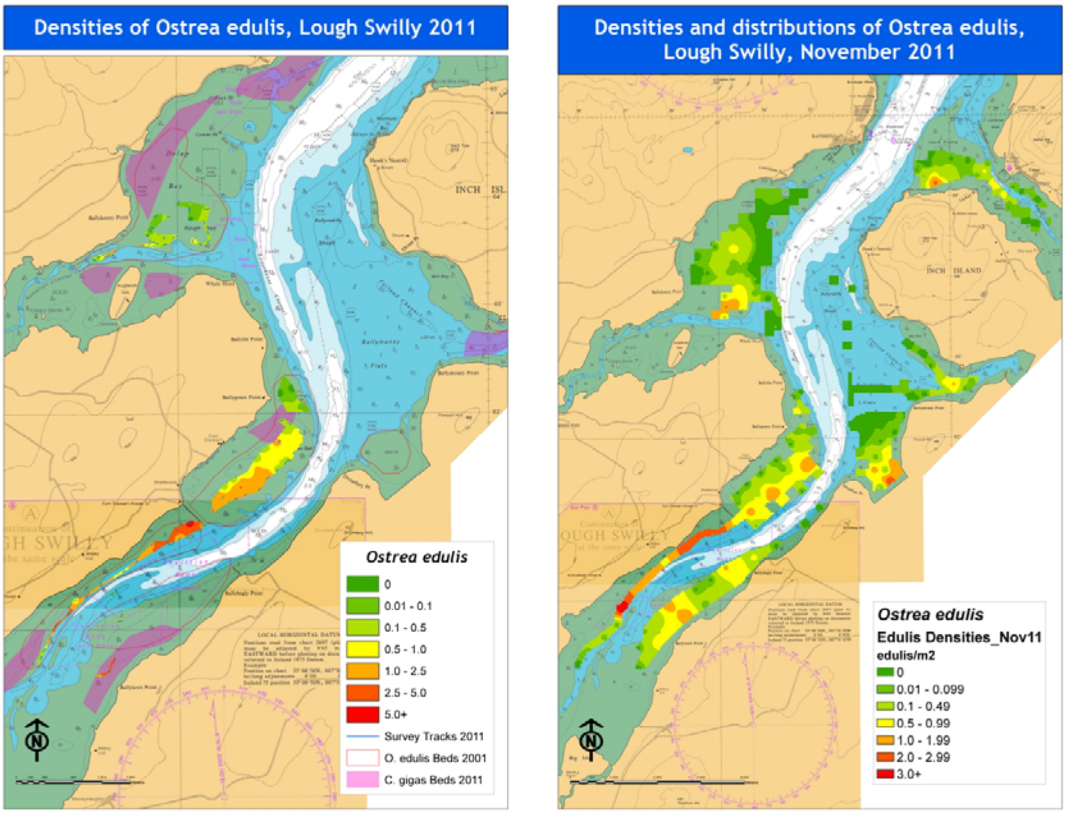


Figure 19. Interpolated distribution and density of native oyster in Lough Swilly in March 2011 (left) and November (right) 2011. Native oyster beds are drawn in the March 2011 map from O'Sullivan (2001). Pacific oyster distribution is drawn from local fishermens' knowledge.

8.6.2 Size composition of native oyster

In March 2011 native oyster ranged in size from 8-105mm and averaged 54±11 mm. Only 2.4% of the oysters measured were above the minimum landing size of 76 mm. Total annual mortality rate (Z), estimated from the linearised portion of the length converted catch curve of the size composition data and using growth parameters of 0.31 (k) and 110 (H_∞), was 1.71±0.19 indicating a past exploitation rate of 82%. The stock was fished in late 2010.

In November 2011 native oysters ranged in size from 14-122 mm and averaged 51.3±15.5 mm. 6.08% of oysters were greater than the minimum landing size of 76 mm (Figure 20).

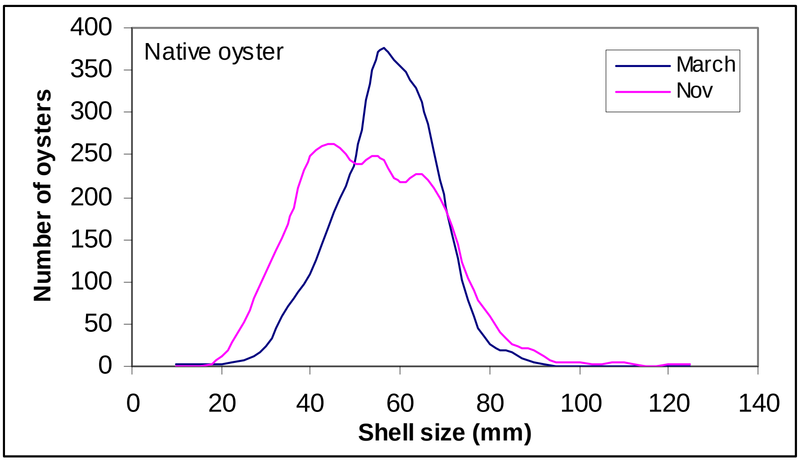


Figure 20. Size distribution of native oyster in Lough Swilly, in March and November 2011.

8.6.3 Distribution and abundance of Pacific oyster

In March Pacific oyster (*C. gigas*) densities ranged from 0-5 oysters m^{-2}. The total number of Pacific oyster estimated for the survey area was 1.07 million oysters (Figure 21).

In November Pacific oyster densities, ranged from 0-8 oysters m^{-2}. However, density at the majority of stations was below 3 oysters m^{-2}. The total number of Pacific oyster estimated for the survey area was 5.64 million.

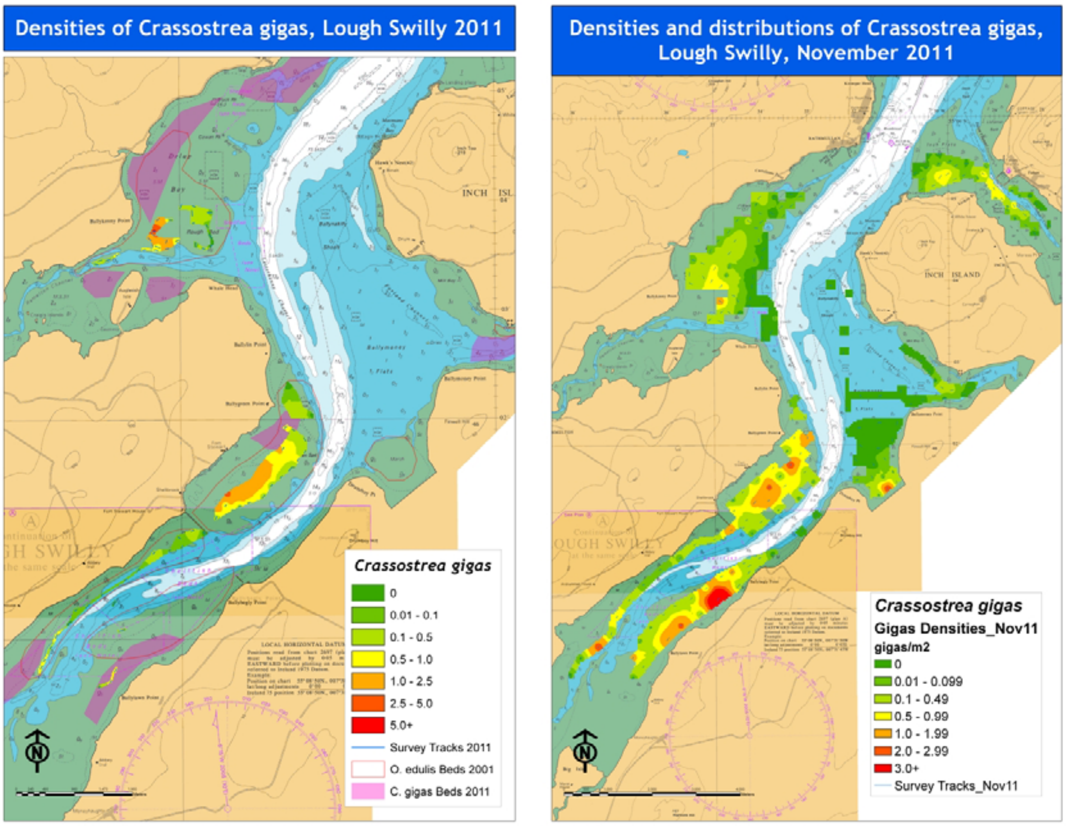


Figure 21. Distribution and density of Pacific oyster in Lough Swilly in March (left) and November (right) 2011. Native oyster beds are drawn in the March 2011 map from O'Sullivan (2001). Additional information on Pacific oyster distribution is drawn from local fishermens' knowledge.

8.6.4 Size composition of Pacific oyster

The size range of Pacific oysters in March was 10-194mm and averaged 81±28mm. The size range in November was 16-205mm with an average size 84.9±25.9mm. There is likely to be a number of age classes present in the population (Figure 22).

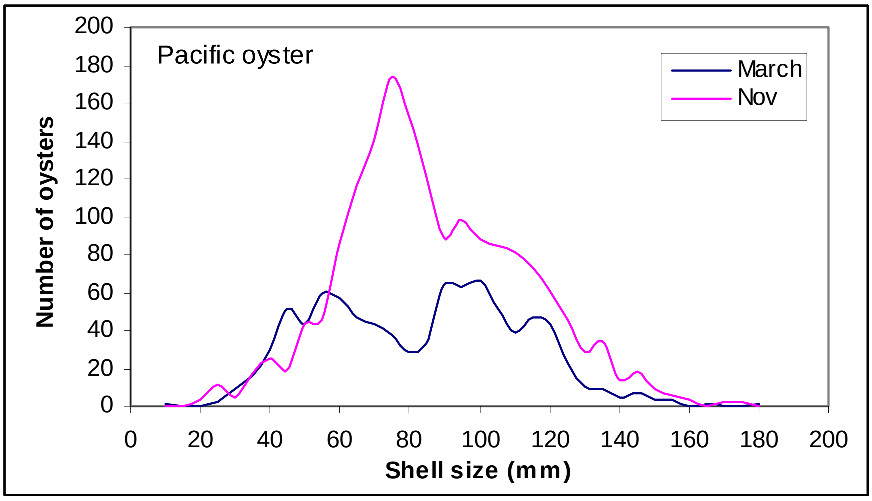


Figure 22. Size distribution of Pacific oyster in Lough Swilly in March and November 2011.

8.6.5 Proportional distribution of native and Pacific oysters

The number of native and Pacific oysters estimated to be in the Lough in November 2011 was 5.1 and 5.5 million oysters, respectively. The distribution of the two species overlaps but Pacific oysters tend to be dominant in intertidal areas and shoreward of native oysters with the latter becoming more common at the edge of channels and in the shallow sub-tidal (Figure 23). Pacific oysters occur on the majority of the native oyster beds as defined by O'Sullivan (2001).

Pacific oysters are widely distributed and established in Lough Swilly. The size distribution data suggests the presence of a number of age classes and it is likely that the population is now self-recruiting and probably originated from spawning activity of Pacific oysters in licenced aquaculture sites. The population supported a commercial dredge fishery in 2011 although the tonnage removed is unknown. Commercial fishing for Pacific oyster in Lough Swilly is a recent development. The presence of commercial quantities of Pacific oyster is not referred to in O'Sullivan (2001), suggesting that Pacific oyster has become more established in the area in recent years. The species may be expanding its distribution in the Lough but only annual monitoring of the beds can determine this. Given the level of fishing activity, fishing mortality rates on Pacific oysters in 2011 were probably quite high and may restrict the capacity of the population to expand further. However, no explicit control measures have been developed.

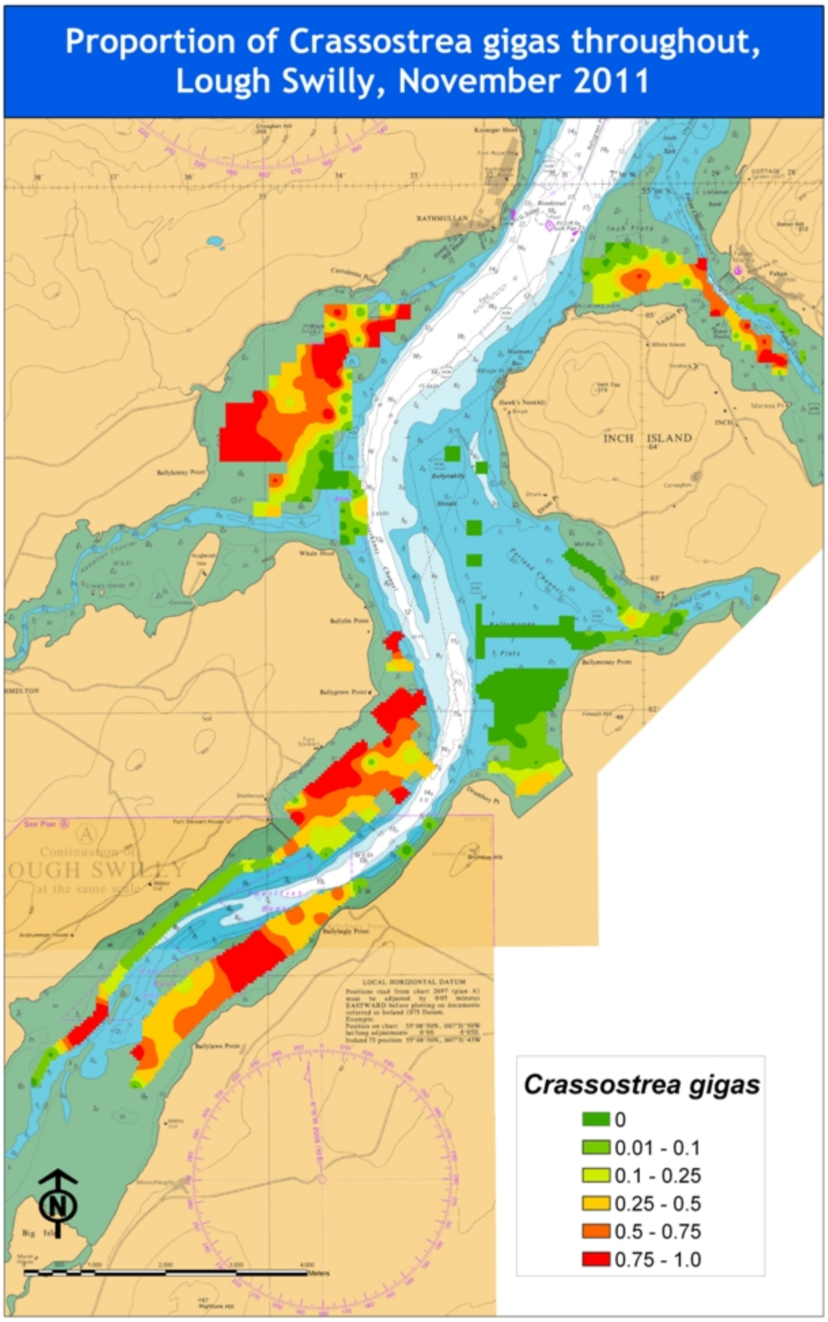


Figure 23. Distribution of Pacific oyster, as a proportion of all oysters, recorded during a dredge survey in Lough Swilly in November 2011.

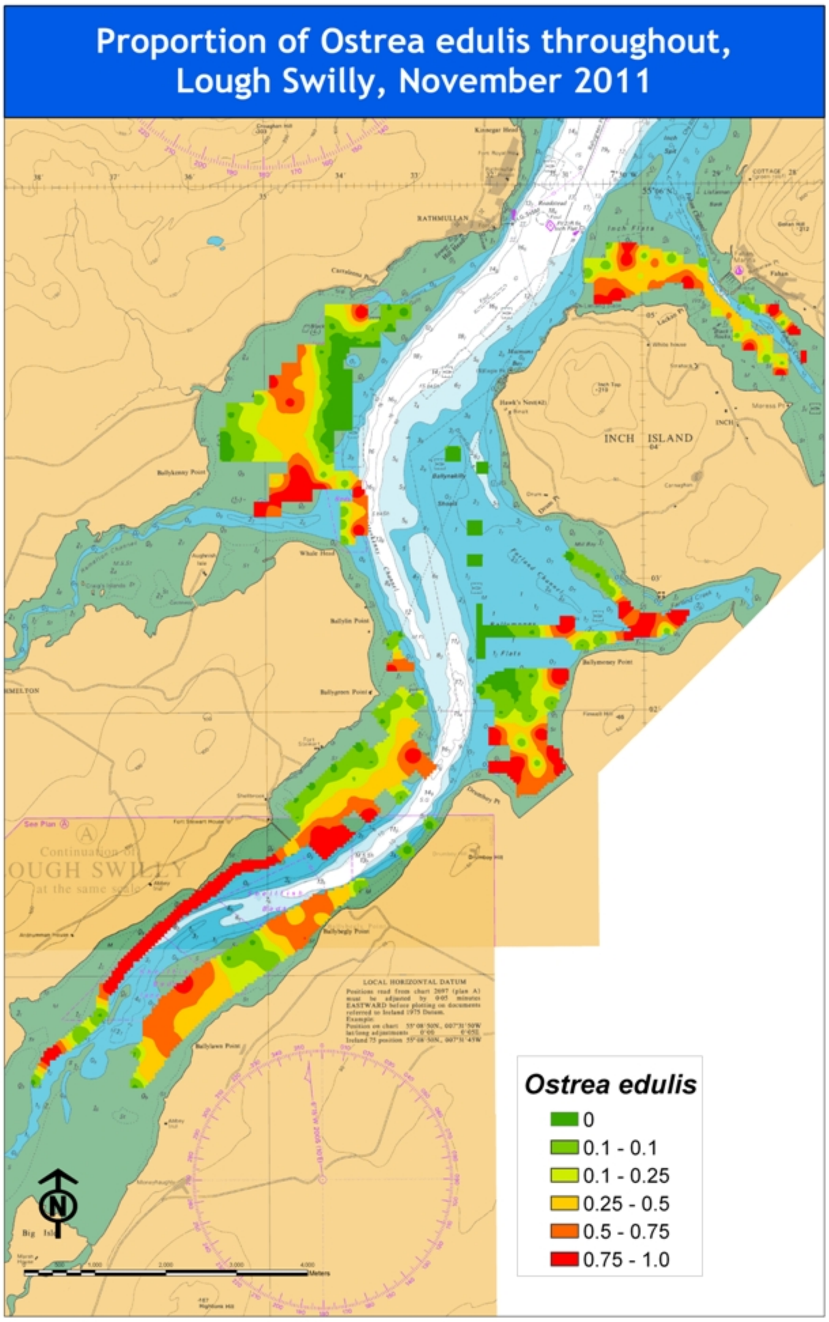


Figure 24. Distribution of native oyster, as a proportion of all oysters, recorded during a dredge survey in Lough Swilly in November 2011.

8.7 *Galway Bay*

8.7.1 Distribution and abundance of native oyster

The distribution of native oysters in Galway Bay is restricted compared to its historic distribution. In April 2011 the main population occurred in a limited area east of a line between Eddy Island and Mweenish Point and north of Rincarna point. Densities in this area were over 2.5m^{-2}. In other areas oysters were either absent or at very low densities (Table 23, Figure 25).

Assuming a dredge efficiency of 35.5%, estimated for oyster dredges in other areas in 2010, the total biomass of oysters in the surveyed area was 34.5±21.5 tonnes. In April six percent of the biomass was over the minimum landing size of 76mm. The surveyed area did not include areas such as the deep channel between Eddy Island and Mweenish which was fished in 2011.

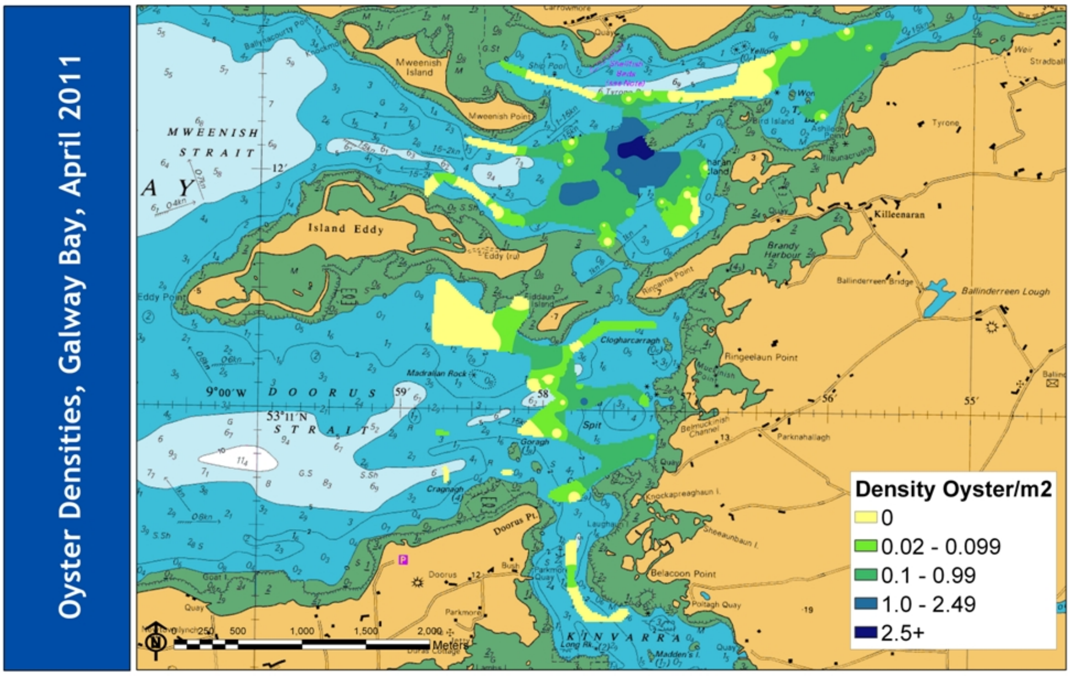


Figure 25. Distribution and density of native oysters in south east Galway Bay in April 2011.

Table 23. Distribution of native oyster biomass in south east Galway Bay in April 2011 assuming a dredge efficiency of 35.5%.

Density (DE=35.5%)	Area (m²)	N	Mean density m²	95% CL density	Number of oysters	Biomass (gms m²)	95% CL Biomass m²	Total Biomass (tonnes)	CL Biomass (Tonnes)
0	587,396	48	0.00	0.00	0	0.00	0.00	0.00	0.00
0.02 - 0.99	492,408	14	0.06	0.08	29,029	2.82	4.06	1.39	2.00
0.1 - 0.99	1,120,743	29	0.44	0.20	498,047	16.55	9.06	18.55	10.15
1.0 - 2.49	230,525	11	1.40	0.39	321,909	47.46	24.75	10.94	5.71
2.5+	33,855	2	4.00	0.44	135,371	108.69	109.52	3.68	3.71
Total	**2,464,927**	**104**			984,356			**34.56**	**21.56**

8.7.2 Size and age composition of native oyster

Repeat surveys in 2011 showed that the percentage of oysters over the minimum size increased from 6% in April to 17% in July, 23% in August and 28% in November.

Size at age estimates were derived by fitting normal distributions, assumed to represent age classes, to the size distribution data for each sampling date. Mean size at age derived from these estimates was, unexpectedly, linear. Fitting the size at age to ages 4+ and 5+ by eye when combined with model estimates for ages 0-3, the von Bertalanffy asymptotic model had growth parameters k = 0.20, L_∞ = 110 and t_o = -0.6 (Figure 27). These estimates are speculative and require verification.

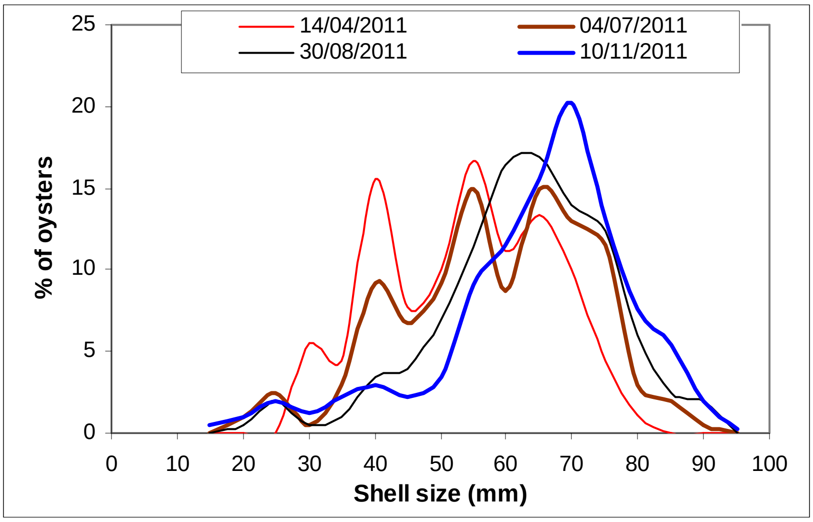


Figure 26. Size distribution of native oysters in south east Galway Bay in 2011.

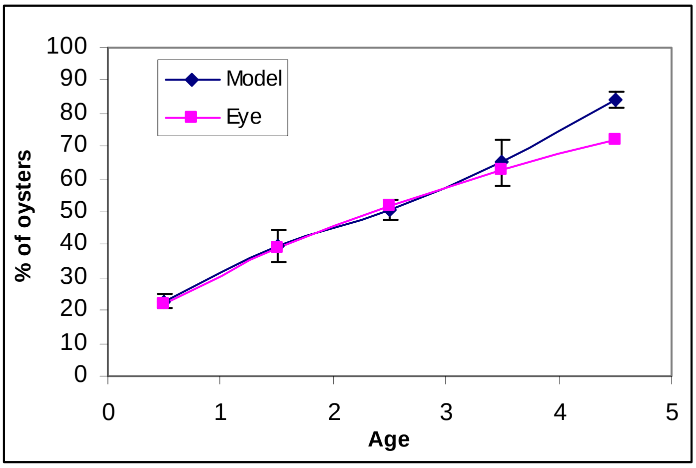


Figure 27. Speculative size at age of native oysters in Galway Bay and the von Bertalanffy model (k=0.2, L_∞ = 110mm and t_o = -0.6) fitted to size at age estimated from the size composition by a combination of model and 'eye' estimates. Error bars are standard deviations of normal distributions fitted to the size distribution data.

8.7.3 Pacific oyster in Galway Bay

Pacific oysters are cultured on the seabed in the Clarin River estuary east of the native oyster survey area under a fishery order issued to the Clarinbridge Oyster Co-operative in 1978. Pacific oysters are the main species of oyster in the river estuary and also occur sporadically on the western third of the order area and at one station further west in the native oyster bed (Figure 28). Given their size (68-144mm) these oysters may be 2-6 years old (Figure 29). There was no evidence of any recent settlement.

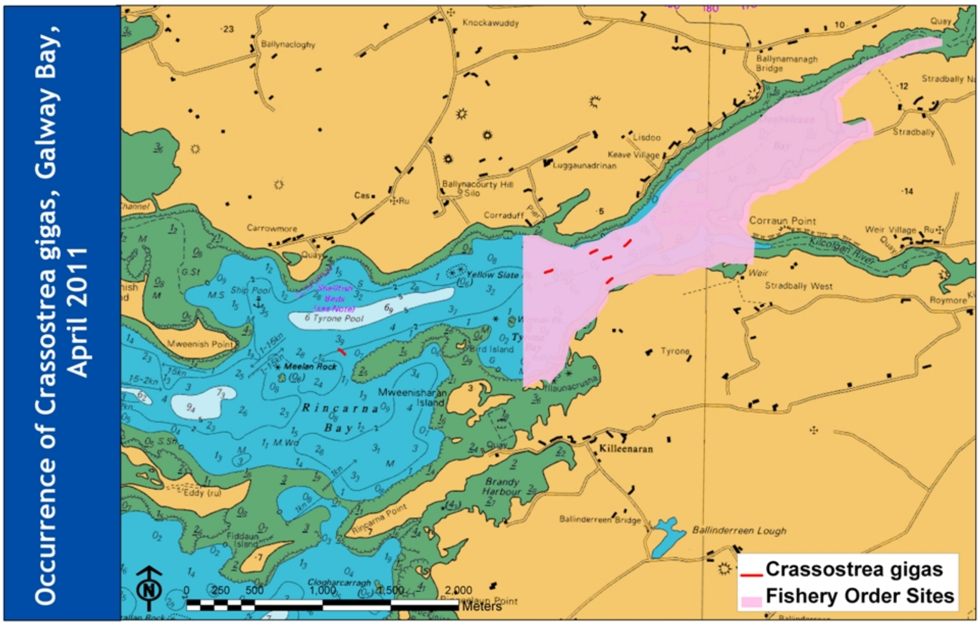


Figure 28. Survey tracks where Pacific oysters were recorded during the 2011 survey of native oysters. Pacific oyster is cultured in the eastern section of the Fishery Order site.

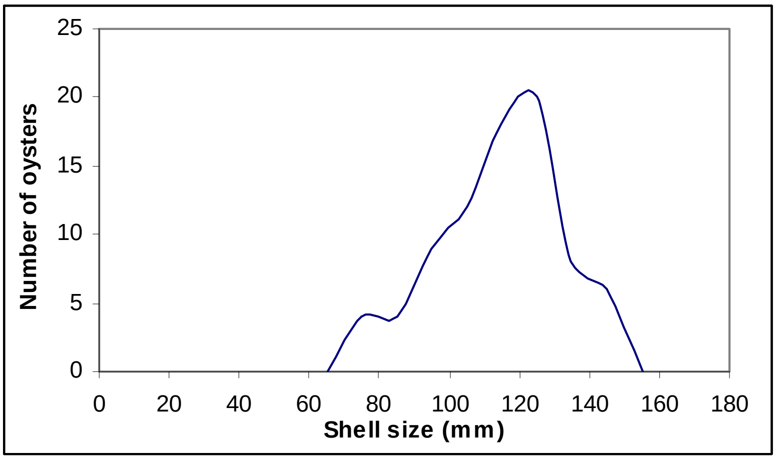


Figure 29. Size distribution of Pacific oysters (*C. gigas*) found on the eastern side of the fishery order area in April 2011.

8.8 Tralee Bay

8.8.1 Fenit Survey 2011

The main oyster bed in Tralee Bay is east of Fenit in the inner Bay. A second bed, in two patches, exists in the outer Bay.

In September densities, corrected for dredge efficiency of 17.5%[1], ranged from 0-65.5 oysters m^{-2} (Figure 30). The total number and biomass of oysters in the survey area (3.57km^2) was estimated to be 41.96million and 1,278.61±1,059.59 tonnes, respectively (Table 24). Approximately 7.9% (100 tonnes) of this biomass was over the minimum landing size of 78mm.

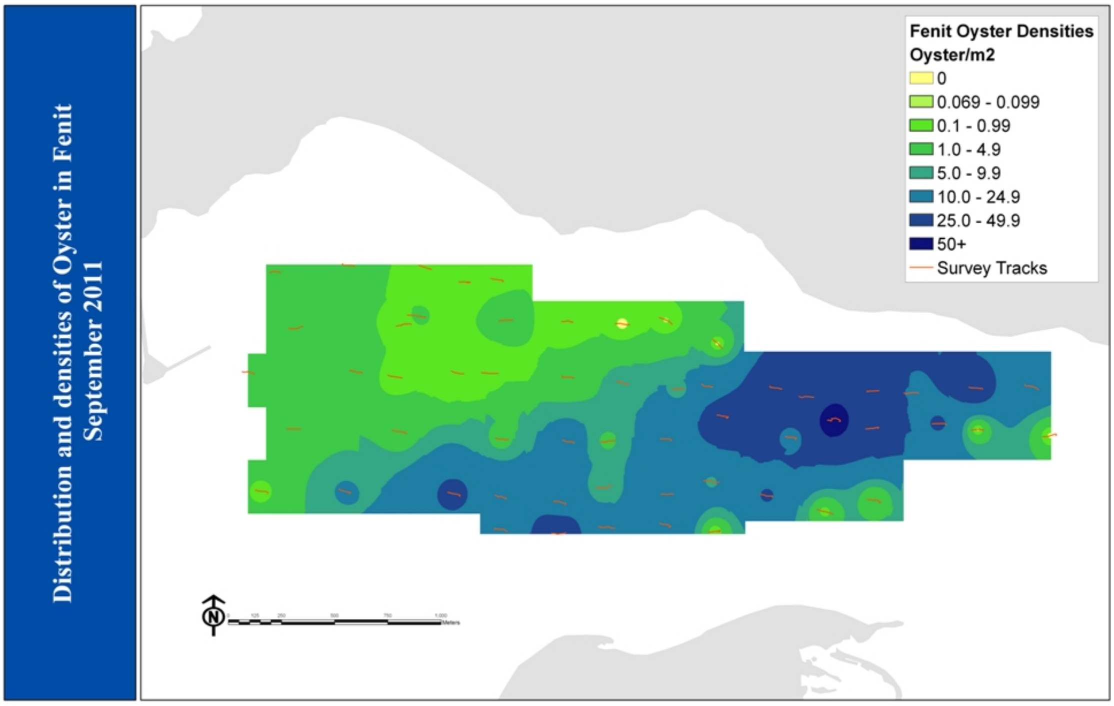


Figure 30. Dredge tracks and contoured densities in the Fenit native oyster bed in September 2011.

[1]Biomass estimates are obviously highly sensitive to dredge efficiency estimates. In this case the 17.5% is based on the unraised estimate for legal size oysters in 2010 relative to the actual landings of legal oysters post the 2010 survey (38.35/170) and an exploitation rate of 77% of legal oysters (estimated from pre and post fishery size data)

Table 24. Density and biomass of oysters in Fenit in September 2011.

Density	Area (m2)	N	Mean density m2	95% CL density	Number of oysters	Biomass (gms m2)	95% CL Biomass m2	Total biomass (tonnes)	CL Biomass (Tonnes)
0	1,897	4	0.00	0.00	0	0.0	0.0	0.0	0.0
0.06-0.099	1,569	2	0.07	0.06	110	2.8	2.6	0.0	0.01
0.1-0.99	505,319	10	0.45	0.33	227,394	22	23.5	11.3	11.9
1.0-4.99	1,023,950	13	2.36	0.60	2,414,947	111	73.5	113.9	75.3
5.0-9.99	484,294	4	7.59	1.43	3,673,369	255	299.4	123.9	145.0
10.0-24.99	1,006,428	13	17.17	1.31	17,281,148	461	355.8	464.0	358.2
25.0-49.99	526,732	10	32.80	1.82	17,277,325	1,012	745.2	533.3	392.5
50.0+	16,609	1	65.51	0.00	1,088,040	1,934	4,613.1	32.1	76.6
Total	**3,566,798**	**57**			**41,962,332**			**1,278**	**1,059**

8.8.2 Size composition of oysters in Fenit

Oysters ranged in size from 4-102mm and averaged±sd 46±20mm. Two 'cohorts' were apparent. The age profile of these oysters is uncertain, however, as growth rate are unknown (Figure 31). Oysters <47mm were much more abundant in September 2011 than in September 2010 indicating a stronger settlement in 2010 (assuming the dominant cohort in Figure 31 is 1+ and not 0+) than in 2009.

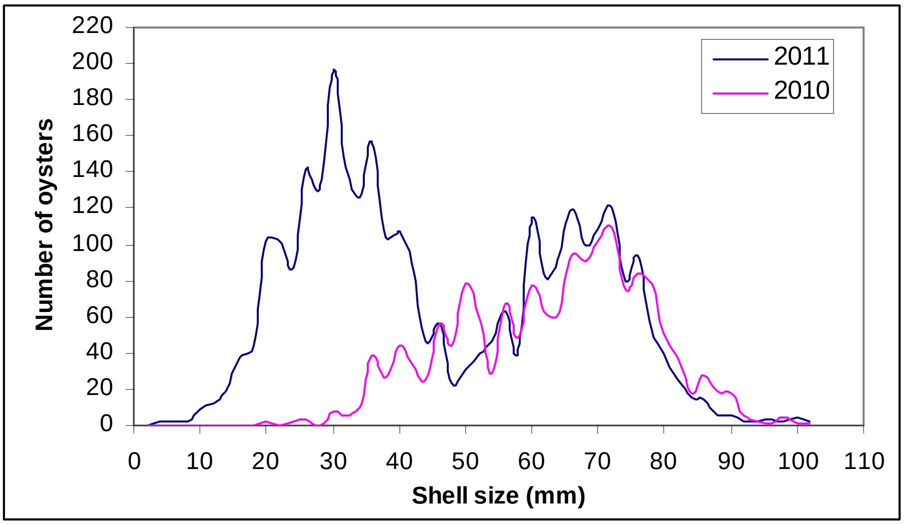


Figure 31. Size distribution of oysters in the Fenit oyster bed in 2010 and 2011.

9 Whelk (*Buccinum undatum*)

9.1 Management recommendations

In the Irish Sea fishery catch rates, landings, effort and biomass have declined. Catch rates are below commercial levels in significant areas of the fishery which previously supported high fishing effort. An area based stock recovery plan should be developed for the southern Irish Sea fishery. In the absence of a recovery plan the negative trends are likely to continue and any future recovery will be protracted. Current management is effected through a minimum landing size regulation. However, this is insufficient as the size at maturity is significantly above the minimum landing size.

9.2 Issues relevant to the assessment and management of this fishery

- The main whelk fishery occurs in the south Irish Sea. A much smaller fishery occurs north of Malin Head, Co. Donegal.
- The fishery is managed by a minimum landing size of 25mm shell width and 45mm shell height.
- Whelk are relatively sedentary and have no pelagic larvae dispersal phase. Therefore, there may be more than one stock in the southern Irish Sea. Biological characteristics such as growth rate and size at maturity also vary geographically in the Irish Sea.
- Area based assessment and management within the Irish Sea may be necessary given the probably complex population structure and spatial variability in growth and reproduction.
- Sampling requirements for length or age based assessments are onerous given the spatial and seasonal variability in size composition and growth rates.
- The size at maturity is well above the minimum landing size and it is, therefore, not feasible to manage solely using MLS. Increasing the MLS to the average size at maturity would make the entire fishery uneconomic.
- Data provision is currently weak and limited to opportunistic sampling at processing plants and provision of catch and effort data by a small number of vessels through the Sentinel Vessel Programme (SVP).
- The number of participating vessels is probably about 30 having declined from approximately 80 at the peak of the fishery. The fishery is open to all polyvalent vessels.

9.3 Management units

Although whelk are common in many areas around the Irish coast commercial sized populations occur only in the Irish Sea south of Howth and to a much lesser extent in a small area north of Malin Head. Whelks do not have a dispersive larval phase so dispersal capacity is limited. Individual stocks almost certainly exist in different coastal areas. In the southern Irish Sea size composition, growth rates and size at maturity all vary spatially suggesting some degree of isolation of stocks in different areas although all of these biological characteristics could also be environmentally determined. The physical environment in the south Irish Sea is also dynamic and dispersive which may also play a role in the dispersal of whelk in the region. Nevertheless, if the objective is to control local fishing mortality and to adjust the minimum size to optimise yields and egg production then separate management units could be identified in the south Irish Sea.

9.4 Landings

The Irish Sea fishery for whelk developed in 1990 and expanded rapidly in response to markets in Korea. Up to 80 vessels were involved in the late 1990s. Landings increased from 96 tonnes in 1990 to almost 6,000 tonnes in 1995 and 1996. A second higher peak in landings of almost 10,000 tonnes occurred in 2003. Landings between 2006 and 2010 averaged 2,788 tonnes. A smaller fishery developed north of Malin Hd. in 2003 when over 600 tonnes were landed. This fishery has since declined.

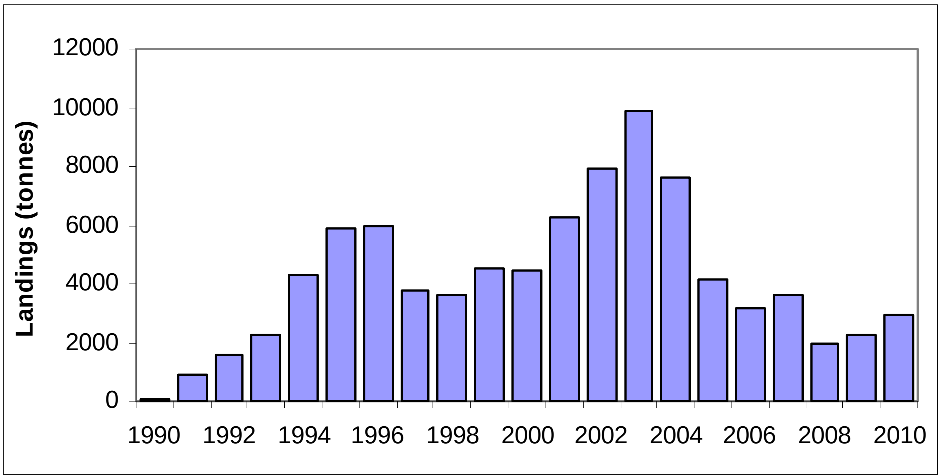


Figure 32. Landings of whelk into Ireland 1990-2010.

9.5 The Irish Sea fishery

9.5.1 Catch rates and distribution of fishing

Catch per unit effort in the Irish Sea whelk fishery declined between 2006 and 2010 (Figure 33). There is, however, strong seasonal and spatial variability in the nominal non-standardised cpue data. Average catch rates in autumn 2010 were less than 1.5kgs.pot^{-1}. CPUE data for the period 1994-1998, reported by Fahy *et al.* (2005), were higher ranging from 0-8.5kg.pot^{-1} with 60% of records between 1.5-3.5kgs.pot^{-1}.

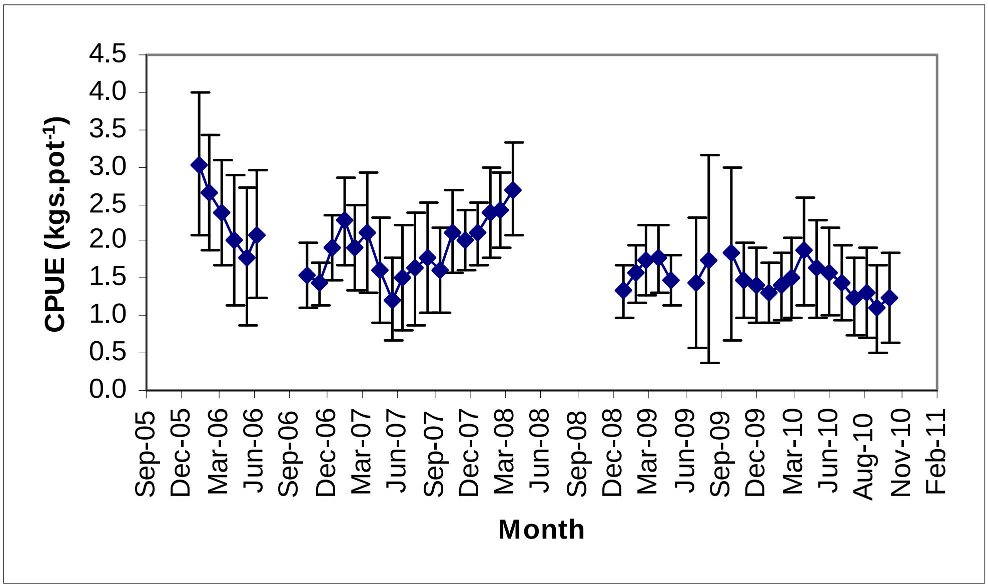


Figure 33. Monthly catch per unit effort (cpue) data for the Irish Sea whelk fishery 2006-2010. All data are from voluntary logbook schemes.

In 2006-2008, catch rates were higher inshore in the south of the area and offshore to the north in the Codling bank area (Figure 34). Catch rates in inshore areas east of Wicklow were generally less than 1.38 $kgs.pot^{-1}$ and less than 1.0 $kgs.pot^{-1}$ over much of this area. In 2006-2008 the distribution of fishing was closer inshore than in the period 1994-1999 reported by Fahy *et al.* (2000) although neither data set represents a census of fishing activity.

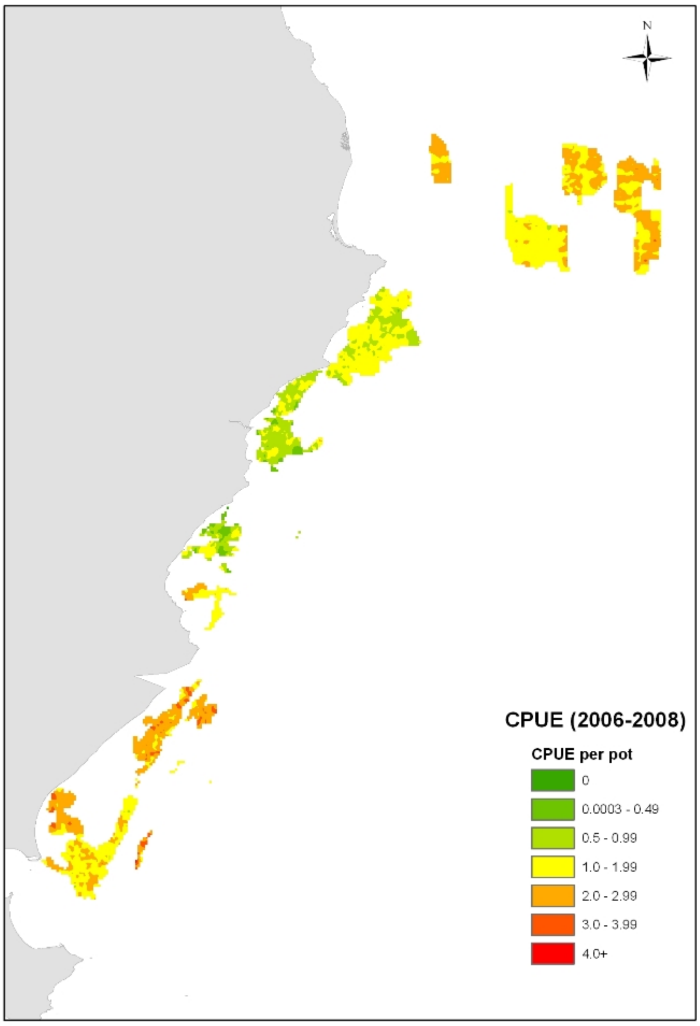


Figure 34. Distribution of whelk catch rates in the southern Irish sea, 2006-2008, expressed as kgs.pot^{-1} of whelk interpolated from 5,090 fishing locations. The data are not a census of activity. Catch rates during the period were higher in the south and offshore in the north of the area. Data are from voluntary logbooks submitted by fishermen.

9.5.2 Size composition

Size composition data by port, for the period 1994-2011, indicate stronger variability across ports than over time. Whelk in the northern (Dublin) and southern (Wexford) areas of the fishery tend to be larger than those in Arklow, Wicklow and Courtown (Figure 35).

Size distributions in the Dublin fishery varied over time. In particular the 2000-2003 data and the 2007 data have very different distributions with the 2007 data dominated by larger whelk. The age composition of the landings is dominated by the 5+ cohort with ages 3+ and 4+ partially recruited to the fishery. Whelks aged 10+ and older are uncommon in the landings.

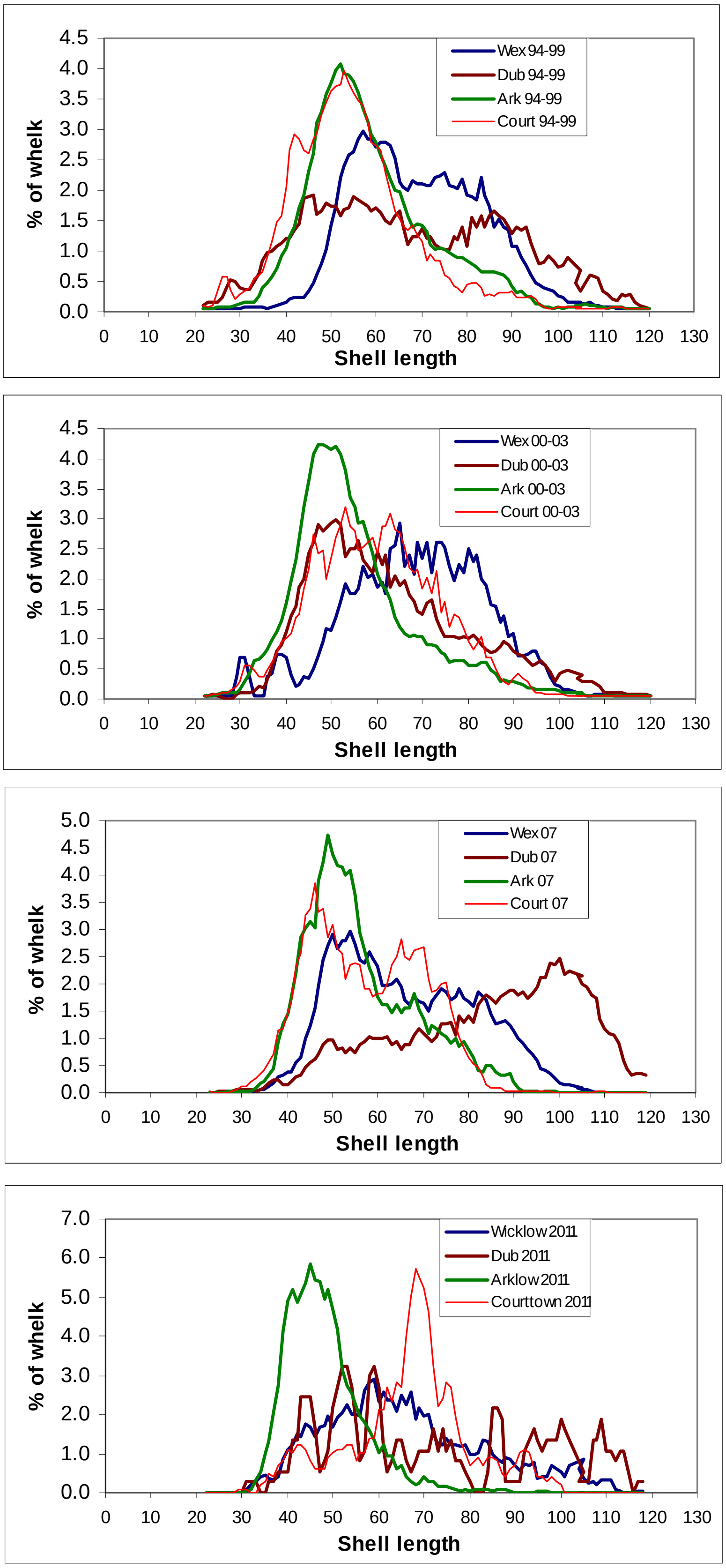


Figure 35. Size composition of whelk in the landings, by area, in the Irish Sea 1994-2011. Date up to 2003 re-constructed from Fahy *et al* 2005.

9.5.3 Biomass and fishing mortality

Estimates of trends in biomass and fishing mortality, from virtual population analysis (VPA), suggest that there has been a significant decline in biomass in recent years. Recruitment peaked during the period 1997-2000, biomass peaked at over 18,000 tonnes in 2002 but declined thereafter reaching a 14 year low of under 6,000 tonnes in 2008. Fishing mortality (F), of fully recruited age classes (5-10 years), ranged between 0.7-0.9. The decline in biomass in the period 2002-2006 followed from high landings of over 6,000 tonnes between 2001-2004 (Figure 36).

Biomass and F estimates from the VPA should be treated with caution as size data were averaged across missing years, procedures for raising sample data to landings were *ad hoc* and a single age length key was used for the entire period and all areas. The biomass estimates for the period 1997-2003 from the VPA are correlated with separate estimates derived from a Leslie depletion (of CPUE) analysis presented by Fahy *et al.* (2005). However, the VPA biomass estimates are on average 30% lower. Biomass estimates from Fahy *et al.* (2005) are also uncertain as the observed level of depletion in catch rate was low and the catch rate data was highly variable.

Nevertheless, the trends strongly suggest that biomass in recent years is about one third of its peak, fishing mortality remains high and there is evidence of local depletion in catch rates. Given that age to full recruitment is 5+, average age at maturity is older than 5+, fecundity is low and there is limited dispersal capacity the fishery and the stock are at risk from further depletion which will take a number of years to reverse.

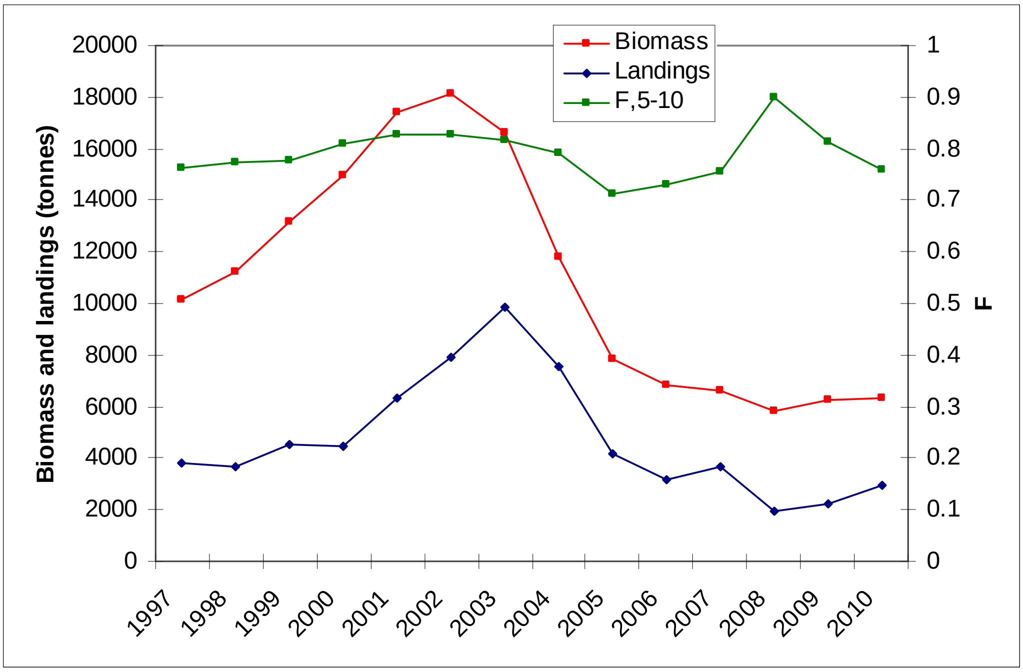


Figure 36. Trends in biomass and fishing mortality rate (F) derived from virtual population analysis. M = 0.2, F_{ter} = 0.5, no tuning, single age length key throughout the series, size composition data aggregated to Irish Sea area and averaged across missing years, raising factors for size composition simply based on overall ratio of sample weight to weight of landings.

9.6 Whelk fisheries outside the Irish Sea

In 2003 a number of surveys were completed in areas other than the Irish Sea to identify the presence and abundance of whelk stocks in these areas (Figure 37). Commercial fishing vessels were commissioned to evaluate catch rates of whelk. In all 13 vessels, fishing out of 11 ports, participated in surveys. This resulted in 894 fishing records (usually strings of pots), 166 boat days and a total of 112,285 pot hauls. The surveys were carried out in counties Donegal, Mayo, Galway, Kerry, Cork and Dublin.

Catch rates were highest in north Donegal, east of Malin Head and in Galway Bay, ranging from 20-64kgs per 10 pots. These catch rates are commercial and fisheries developed for whelk east of Malin Head in 2002 and in inner Galway Bay in 2004. Catch rate south of Baltimore was 9.2kgs per10 pots. Surveys offshore from Greencastle and north east of Malin Head and a second offshore survey north off Malin Head by a vessel out of Burtonport resulted in relatively low catch rates (11.9 and 4.7 kgs per 10 pots, respectively). Commercial catch rates of whelk therefore occurred in a relatively small area in inshore waters east of Malin Head. All surveys west of Malin Head off north west Donegal and south to Donegal Bay yielded very low catch rates.

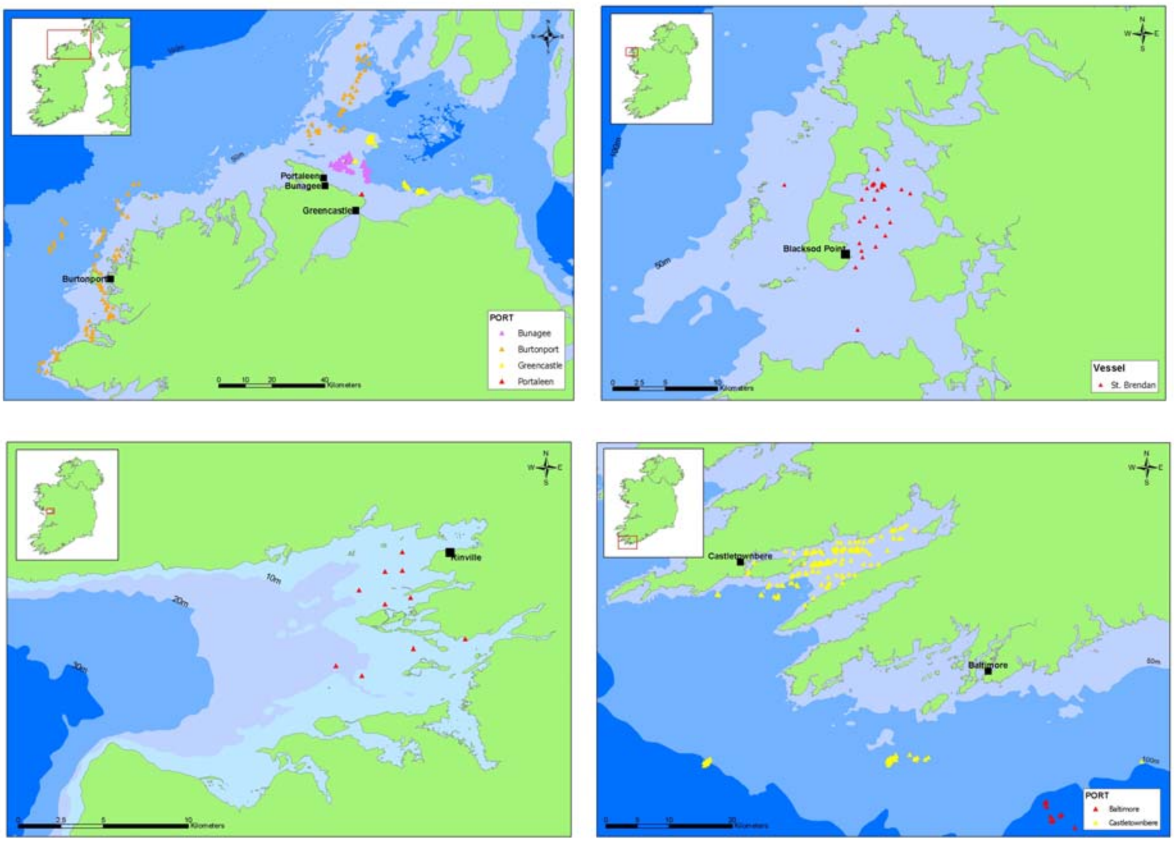


Figure 37. Locations of whelk surveys, outside the Irish Sea, in 2003 (from Hemer *et al* 2007).

Table 25. Catch rate of whelk from surveys out of 12 ports in 2003 in order of decreasing average catch rate (from Hemer *et al* 2007).

Port	County	N (records)	Catch rate (kgs per 10 pots)		
			Mean	s.d.	Max
Portaleen	Donegal	135	64.55	28.86	113.89
Bunagee	Donegal	155	30.49	8.95	57.40
Renville	Galway	14	20.44	15.94	54.67
Lough Swilly	Donegal	23	12.52	6.82	30.06
Greencastle	Donegal	238	11.96	10.19	35.14
Baltimore	Cork	12	9.21	8.03	24.60
Castletownbere	Cork	171	2.02	1.78	10.25
Burtonport	Donegal	93	1.70	3.41	15.91
Blacksod	Mayo	28	1.61	0.98	3.54
Howth	Dublin	28	1.45	3.56	15.38
Kilcar	Donegal	20	0.13	0.07	0.27
Killybegs	Donegal	15	0.00	0.00	0.00

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11 Glossary

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

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

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

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

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

Catch curve A curve describing the change (usually exponential decline) in numbers of fish in the catch at each successive age/length.

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

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

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

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

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

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

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

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).

Length converted catch curve A curve describing the change (usually exponential decline) in numbers of fishing in successive size groups after adjusting for the different periods of time required for fish to grow from one length group to the next using information on their growth rate.

Linearised length converted catch curve A linearised form (by transformation of data on numbers at length to natural logs of numbers at length) of the length converted catch curve.

Management Plan is an agreed plan to manage a stock. With defined objectives, implementation measures, 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.

Pelagic (fisheries) Fish that live in the water column and are typically targeted with various mid-water trawls, nets or lines.

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.

Steady state conditions When the population processes in a stock, namely recruitment, growth and mortality rates are 'constant' over a given period of time.

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

VPA Virtual Population Analysis, a method of reconstructing the past biomass of a cohort or cohorts of fish in a population "a thriving maritime economy in harmony with the ecosystem and supported by the delivery of excellence in our services"

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