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This report represents the results of marine and freshwater scientific work carried out by Marine Scotland Science, with survey work conducted by Marine Ecosol.

Survey of the Scottish Solway Firth Cockle Grounds 2015

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1.0 Introduction

1.1 General

This report presents the results of the 2015 survey of cockle (*Cerastoderma edule*) stocks in the Scottish Solway Firth. It continues a series of surveys conducted between 1990 and 2009 by Marine Scotland Science (MSS) (previously Fisheries Research Services) and a further survey in 2013, conducted by Marine Ecological Solutions Ltd under contract to Marine Scotland (Stamp *et al*., 2013).

Results of surveys prior to 2006 were used to inform management of the fishery and to set total allowable catches (TACs) for the commercial cockle fishery in the Scottish Solway Firth. Since 2006, cockle harvesting in the Scottish Solway Firth has been subject to an Appropriate Assessment to take into account the feeding requirements of overwintering shorebird populations within the Special Protection Area (SPA) in the Inner Solway Firth (Howell *et al*., 2007) and management advice from Scottish Natural Heritage (SNH). The Appropriate Assessment has involved the application of an individual-based shorebird interaction model and latterly spreadsheet models which predict the quantities of bivalve molluscs required to maintain high survival rates of oystercatcher and knot populations in the Solway SPA (Stillman and Wood 2013). Providing the data required for these models engendered changes to both the timing and the scope of the Solway cockle survey. Between 1993 and 2006 surveys were conducted in April or May, but from 2007 onwards the surveys were later in the year to provide estimates of '0' group cockles (individuals that are less than one year old) which constitute an important food source for overwintering birds. Sampling was also extended to include other species of bivalve molluscs. A detailed account of the history of the fishery and its management is provided by Howell *et al.* (2012a).

In 2011 the Scottish Solway Firth was closed to cockle fishing under the Inshore Fishing (Prohibition of Fishing for Cockles) (Solway Firth) (Scotland) Order 2011 and has remained so since. The closure was in response to low stock levels at the time, local concerns about the fishery and the desire of Scottish Government to establish a robust management regime that would ensure sustainability and control of harvesting. Following reports of an increase in cockle stock abundance, Marine Scotland commissioned a survey of the grounds in 2013, and between November 2013 and July 2014 carried out a management study, during which the cockles were hand gathered at a commercial scale over six weeks under a scientific derogation (Marine Scotland, 2015). Although poor cockle yields and difficult market conditions

meant that the study was terminated earlier than anticipated, it provided useful insights into future management options and controls.

The 2015 survey was commissioned to provide up to date stock information, part of the process of determining whether the Solway cockle stocks could support a harvest without any detrimental effects on protected shorebird populations. The results of the survey, specifically estimates of abundance and biomass of cockles and co-occurring bivalves, were provided to Marine Scotland and SNH in October 2015.

1.2 The 2015 Scottish Solway Cockle Grounds Survey

The 2015 Solway Firth cockle survey was carried out between August 10th and 20th by staff from Marine Ecological Solutions Ltd (Marine EcoSol) and their sub-contractors Hebog Environmental Ltd, working under contract to Marine Scotland. The contractors were responsible for planning and executing the survey, reporting on methodology and outcomes (Goudge *et al*., 2015) and providing the data collected to MSS for analysis.

Prior to the start of the survey, the contractors visited all the fishing grounds to identify suitable access locations, organise access permissions and to assess risks associated with carrying out the survey. A survey plan and risk assessments were provided to MSS for review and approval before the survey took place.

2.0 Survey Methods

2.1 General

The grounds surveyed were the same as those surveyed in 2009 and 2013. They are shown in Figure 1 and listed below.

Survey Area (Site)	Previous MSS site code	2015 Site Codes
Barnhourie	A	BAR
North Bank	B	NOR
Carsethorn	C	CAR
Auchencairn Bay	D	AUC
Orchardton Bay	E	ORC
Glenisle & Rough Island	F & G	ROU[1]
Wigtown Bay	I	WIG
Fleet Bay	O	FLE
Arbigland	P	ARB

The names of the various fishing grounds or banks are those used by cockle fishermen during the early 1990s. They have been retained in this report for continuity: Survey area BAR, Barnhourie or Barnhourie Bank, includes the Barnhourie Bank and the Mersehead Sands; Area NOR, North Bank, refers collectively to the Blackshaw Bank, Priestside Bank, Middle Bank, and North Bank, as shown within the un-surveyed region on Admiralty Chart 1346 (2001 edition).

As in previous Solway shore-based surveys, All Terrain Vehicles (ATVs) were used to collect samples at pre-determined randomly generated locations (stations), during periods of low water. Fishing grounds were accessed via public or private shore based access points in all cases except Carsethorn Bank which was accessed by boat. Samples from the Glenisle side of the survey area called Glenisle & Rough Island (ROU) were collected on foot.

A stratified random sampling design (first stage) was employed at each fishing ground. At Barnhourie a two-stage adaptive sampling design (Francis, 1984; Bailey *et al.*, 1998) was used to target high density areas of *C. edule*, identified during the

[1] Sampling areas Glenisle & Rough Island were combined during the 2015 survey (identified as ROU).

first sampling stage. Computer generated random sampling positions were uploaded to Global Positioning Systems (GPS) equipment mounted on the ATVs or carried by hand.

2.2 Stratified Random Survey Design

Stratified random surveys were carried out on North Bank (NOR), Carsethorn (CAR), Auchencairn (AUC), Orchardton Bay (ORC), Rough Island & Glenisle (ROU), Wigtown Bay (WIG), Fleet Bay (FLE), Arbigland (ARB).

For each of the areas, a notational grid (defining a number of strata) was projected over the extent of the cockle ground. Within each stratum, one quadrat sample was taken from two randomly generated coordinates (referred to as stations or replicates). Each replicate sample was assigned an alphabetical designation. The randomly generated positions were created using Hawth's Tools suite (Beyer, 2004) within Arc GIS 9.2. These positions were computed prior to surveys and then located using handheld GPS units on site.

2.3 Stratified Random Survey Design and Adaptive Procedure

The two stage adaptive survey procedure, introduced in 1998 (Bailey *et al.*, 1998), was used on Barnhourie Bank (BAR) in 2015. The first stage consisted of a conventional stratified random survey based on a grid as described in section 2.2. The second stage involved allocating additional stations to strata based on the mean square abundance of 2+ cockles (i.e. those two years and older) observed during the first stage. This increased the number of samples taken in the areas of highest density of commercial sized (2 years and older) *C. edule*. The number of additional stations sampled in Stage 2 was set to 25% of the total number of stations (Bailey *et al.*, 1998) in stage 1. These are shown in Appendix 1. The cockles gathered in Stage 2 were also aged, measured and weighed. A full description of the adaptive sampling method is given in the 1998 survey report (Bailey *et al.*, 1998).

2.4 Quadrat Sampling

At each station, bivalves were sampled using established quadrat surveying methods (Howell *et al.,* 2012b). All samples were taken using a 0.1 m^2 quadrat frame, from which sediment was removed to a depth of 100 mm and passed through a 5 mm mesh sieve. All bivalves retained in the sieve were placed in uniquely labelled sample bags and notes taken (using the same unique references) regarding the presence and absence of bivalves within the sample. Any observations relating to the accessibility of sampling stations and whether or not samples were obtained were also recorded. In some cases the substrate, e.g. rock, the presence of sea grass, mud or water covering the station, precluded sampling.

2.5 Laboratory Procedures

All bivalves sampled during the survey were measured and weighed and all whole and un-damaged cockles were aged.

Any damaged cockles were aged where possible, measured if a complete valve allowed an accurate length measurement (noted as 'Broken') and weighed if gaping but otherwise undamaged (noted as 'Open'). Damaged cockles lacking a complete valve, or broken in a way which precluded an accurate length or weight measurement were still recorded (noted as 'Broken and Incomplete') and used in the estimation of abundance (but not of biomass). The same approach was applied to other damaged (non-cockle) bivalve species.

Weights were determined using digital balances, precise to 0.01 grams, calibrated with test weights prior to first use. Length measurements were made using Vernier callipers, three units of which were digital, and provided measurements in millimetres precise to two decimal places. The fourth set of Vernier callipers was analogue and survey staff using this unit recorded measurements to whole millimetres only. For the workup of the data, all lengths were therefore rounded to the nearest whole millimetre below.

Cockles were aged by counting external growth bands/ridges. Cockles without growth ridges were termed the 'zero' age class. For quality assurance purposes, members of the survey team with more experience of aging *C. edule* were paired with less experienced individuals to provide guidance and confirmation.

All biological data were entered in a spreadsheet in a format prescribed by MSS which linked the data to station reference numbers. Information on the stratum area for each ground, along with the proportion of each strata available as bivalve habitat (i.e. the proportion of the stratum below Mean High Water Springs (MHWS) that comprised beach sediment) was also provided for use in the analysis. In addition, sampling station coordinates (latitude and longitude), and details of the outcome of sampling at each station (i.e. whether or not samples were obtained and if cockles were found) were provided (Goudge *et al*., 2015).

2.6 Data Analysis

The following bivalve species were identified during the 2015 survey:

- Thin tellin *(Angulus tenuis)*
- Common cockle *(Cerastoderma edule)*
- Banded wedge shell *(Donax vittatus)*
- Bean-like tellin *(Fabulina fabula)*
- Baltic tellin *(Macoma balthica)*
- Rayed trough shell *(Mactra stultorum)*
- Sand gaper *(Mya arenaria)*
- Bivalve mollusc *(Nucula nitidosa)*
- Cut trough shell *(Spisula subtruncata)*

Abundance and biomass estimates and the associated variance were calculated for cockles (*C. edule*) and Baltic tellin (*M. balthica*) as individual species groups as described below. The seven other bivalve species were combined into a single group called 'other bivalves'. Due to the low abundance of these 'other bivalves' (comprising ~2.5% of the total bivalve abundance and ~7% of non *C. edule* abundance), no further analysis was conducted on data from this group.

Data were loaded into the R statistics package (version 3.2.0) (R core team, 2015) and screened for errors. As in previous surveys, data from any bivalves less than 5 mm in length were not included in the analysis (Stamp *et al.,* 2013). Samples from stations within the boundaries of the local nature reserve in Wigtown Bay, where cockle gathering is not permitted were obtained accidentally and were not included in the analysis. Predicted weights of each *C. edule* and *M. balthica* sampled were derived from the fitted length-weight relationships (described in section 2.6 below) and these, as opposed to the measured weights, were used in subsequent calculations.

The estimates of *C. edule* and *M. balthica* abundance and biomass for each fishing ground were calculated in R as follows. For each of the sampled strata the mean density (abundance or biomass) of each age (or length) group was raised to the area of the stratum and stratum variance of the mean calculated. The estimates were then summed across the strata to generate an estimate of the overall abundance or biomass and variance of the estimates were calculated. In some cases only one

sample was taken within a stratum because the second station was inaccessible or located on land or rock. In such cases the single value was assumed to be the mean with zero variance. Abundance and biomass densities of cockles by age class and for all ages, on each ground, were calculated by dividing the estimated abundance or biomass by the area of the ground surveyed.

Outputs in terms of abundance and biomass estimates of *C. edule* and *M. bathica* for each mm length category, in each of the strata sampled, were also provided for use in the bird models which examine feeding requirements of the bird populations of the Solway Firth.

2.7 Length-Weight Relationships

For *C. edule,* length and weight data from all fishing grounds were natural log transformed to linearise the relationship between weight and length. Exploratory plots were used to identify any outliers, which were removed before further analysis.

The model

log (weight) ~ log (length) + ground + log (length):ground (1)

was fitted to the dataset.

This model assumes that log (weight) is linearly related to log (length), but allows the intercept and slope of the relationship to vary between fishing grounds. Attempts were made to simplify this model by removing first the interaction between ground and log (length) (between-ground differences in slope) and then the main effect of ground (between-ground differences in intercept) with model selection based on Akaike's Information Criterion (AIC). However, the model could not be simplified as the interaction between ground and log (length) was highly significant ($p < 0.0001$).

The differences in length-weight relationships (both intercept and slope) between fishing grounds were investigated on a pairwise basis, with p-values corrected for the number of comparisons using Holm's procedure (Holm, 1979). Neighbouring fishing grounds were combined if there was no significant difference between their length-weight relationships (at the 5% level, adjusted for the number of comparisons). Model (1) was then refitted to the data to estimate the intercept (α) and slope (β) for each group of fishing grounds.

The back transformed length-weight relationship for each group of fishing grounds is then:

$weight = a \times length^{b}$

where

$a = \exp(\alpha + 0.5s^2)$; $b = \beta$

and s^2 is the estimate of residual variability from model (1) which is used to avoid bias when back-transforming from the logarithmic scale (Sprugel, 1983). This relationship was used to calculate predicted weights for all individuals for which lengths were available.

In cases where individual length was missing (~2% of *C. edule* recorded; Table 1), the following rules were applied to generate predicted weight. If age was recorded the mean predicted weight for the relevant ground and age category was used. If no age was recorded, the mean predicted weight for the relevant ground and Strata.ID was used. If no age was recorded and there was only one individual in the strata the mean predicted weight for the relevant ground was used.

C. edule Length-weight Relationships

The post-hoc pairwise testing grouped Auchencairn Bay, Orchardton Bay and Rough Island and Glenisle together. Carsethorn and Arbigland were combined into another group and all other sites were deemed to have significantly different length-weight parameters.

Although Orchardton Bay had a low abundance of cockles compared to the other grounds, the length-weight relationship was found to be reliable for providing predicted weights.

Area	A	B
Wigtown Bay	0.000216	3.151619
Fleet Bay	0.000258	3.130791
Barhourie	0.000352	3.002939
Auchencairn.plus	0.000304	3.09361
North Bank	0.000163	3.25286
Carsethorn.plus	0.000234	3.147672

***M. balthica* Length-weight Relationship**

As with *C. edule*, all *M. balthica* length and weight data were natural log transformed and plotted to identify outliers which were removed.

Due to the much lower abundances of *M. balthica* (>30% of grounds had less than 10 individual *M. balthica*), the length-weight relationship was assumed to be common across fishing grounds and a single length/weight relationship (below), was estimated as described above and applied to samples from all grounds.

Weight (g) =0.000298 Length(mm)$^{2.869549}$

If length data were missing predicted weights were calculated using the mean predicted weight for the relevant ground and Strata.ID.

3.0 Results

3.1 General

Samples were obtained from 499 stations during the 2015 survey (Table 1). For the adaptive survey at Barnhourie Bank, 140 stations were sampled during Stage 1 and 48 during Stage 2. Various factors including tidal state, inaccessibility of stations and poor visibility (which reduced sampling efficiency) meant it was not possible to obtain samples at all stations as originally planned. Safe crossing of the River Lochar to access North Bank presented the greatest logistical challenge and although samples were eventually obtained from the majority of stations on the bank, the lack of time available precluded 2nd stage adaptive sampling at this site. Detailed maps of sampling locations in each area and outcomes are given in Goudge *et al*. (2015).

3.2 Cockles (*C. edule*)

Overall, sampling at 190 stations yielded no cockles and the remaining 309 stations yielded 3,906 cockles (Table 1).

Estimates of abundance and biomass of cockles, by age category and for all ages combined, for each of the grounds surveyed, are presented in Table 2. Results of adaptive sampling at Barnhourie are shown in Table 3. Estimates of abundance and biomass density of cockles by age category are given in Tables 4 and 5. Figure 2 illustrates the age composition on the different grounds. A comparison of the 2013 and the 2015 survey results, and a summary of the survey results 1990 – 2015, are

provided in Tables 6 and 7, respectively. Estimates of biomass and abundance by length category, as provided for management advice, are given in Appendix 2.

The overall biomass estimate, for all ages on all grounds of 13,366 tonnes in 2015 was less than in 2013 (14,242 tonnes) (Table 6) and a greater proportion of the biomass in 2015 was comprised of under-aged ('0' group and 1 year old) cockles (Table 7B) than in 2013.

The largest grounds, Barnhourie and North Bank, made the greatest contribution to the overall biomass estimate in 2015, although biomass densities were low compared to some of the other grounds (Table 6). At Barnhourie, 1 year old cockles comprised over 50% of the estimated biomass and 65% of the abundance (Tables 4 & 5 and Figure 2), but the abundance and the abundance density of the '0' group was low. In contrast, on North Bank '0' group cockles were the most numerous, making up around 70% of the estimated abundance but only 7% of the biomass. Commercial sized cockles (2+) comprised 46% and 49% of the biomass at Barnhourie and North Bank, respectively (Table 5).

The highest estimates of biomass densities from the 2015 survey were at Carsethorn and Wigtown. The estimated biomass at Carsethorn was higher than in 2013 despite the reduced survey area (Table 6). Commercial aged cockles comprised 57% of the biomass estimated at 1,427 tonnes (Table 5) and both '0' group and 1 year old cockles were well represented in the samples (Table 4, Figure 2). The area surveyed at Wigtown in 2015 was much smaller than that in 2013 and this is reflected in the overall biomass estimate (Table 6). Despite this, the estimated biomass density in 2015 was similar to that in 2013 (Table 6), and age classes 1 to 4 were well represented (Figure 2).

Of the remaining grounds, only Fleet Bay made a notable contribution to the overall biomass estimate (Table 6) and both biomass and biomass density were much higher than in the 2013 survey. Two year old cockles comprised over 79% of the estimated 1,367 tonnes. Biomass densities estimates for Auchencairn, Orchardton, Glen Isle and Rough Island and Arbigland were generally low (Table 6) with variable representation of year classes (Figure 2).

3.3 Baltic tellin (*M. balthica)*

Macoma balthica were present in samples from 277 of the 499 stations; a total of 2,164 were sampled (Table 8). Estimates of the abundance and biomass of *M. balthica*, all sizes > 5 mm on each of the grounds are presented in Table 9. These include *M. balthica* present in samples obtained during the Stage 2 adaptive

sampling at Barnhourie. Size composition of individuals in the samples is illustrated in Figure 3. Estimates of *M. balthica* biomass and abundance by length category, as provided for management advice are given in Appendix 3.

The overall abundance estimate for *M. balthica* was 5,072 million and the estimated biomass was 2,060 tonnes. The abundance and biomass density estimates for *M. balthica* at North Bank of 86.9 / m^2 and 36.6 tonnes / km^2, respectively, were greater than those on any of the other grounds surveyed and North Bank accounted for 76% of the overall *M. balthica* biomass. Estimated densities of *M. balthica* at Carsethorn exceeded those for Barnhourie (Table 10), but Barnhourie contributed more to the overall biomass estimate, reflecting the larger total area surveyed. Very few *M. balthica* were recorded on the other grounds which collectively accounted for only 3.1% of the overall biomass, and abundance and biomass densities were low.

4.0 Discussion

The series of cockle surveys in the Solway Firth, conducted by MSS, provides detailed information on the cockle stock which extends back to 1990 (see Howell *et al*., 2012a and 2012b and references therein). Between 1993 and 2006 surveys were conducted in April or early May, and the results were presented along with a detailed discussion of year class survival and population trends. The change in the timing of the survey in 2007, to take place in July and August after the main period of spat settlement, reflected the need to assess the availability of '0' group cockles which are an important food resource for shorebirds over winter. The inclusion of the '0' group, and the difference in the survey timing, mean that the abundance and biomass estimates from 2007 onwards are not directly comparable with those from earlier surveys.

The total area surveyed and the grounds covered in any one year have varied over the survey series (see Table 7A) and this should be also considered when comparing the overall biomass (all grounds combined) and abundance estimates. The total survey area in 2015 was 88.29 km^2. Although the 2015 survey included all the grounds, the total survey area was less than the 102.17 km^2 achieved in 2013, but comparable with that in the 2008 survey (Table 7A). Whilst every effort has been made to maintain the survey extent, the distribution of sediment on the beds, tidal conditions, weather and other logistical constraints have meant that it is not always possible. Trade-offs have also been made with respect to the methodology and which grounds were included in the survey. For example, conducting a two stage adaptive survey on the larger grounds (Barnhourie and North Bank) as well as surveying Wigtown and Fleet Bay in any one year has rarely proved possible.

Estimates of the densities of cockles have therefore been included in this and earlier reports to provide an indicator of stock condition on different grounds and enable comparison between years, although with periodic surveys it is more difficult to evaluate year class survival.

The overall cockle biomass estimate for all the grounds in the 2015 survey of 13,366 tonnes is less than the 14,242 tonnes estimated in 2013 although the biomass density (all ages all grounds) was slightly higher in 2015 than 2013. The lower biomass estimate may in part reflect the survey coverage at Wigtown in 2015 which was very limited; however, coverage of other grounds was comparable to that achieved in 2013. As in previous surveys most of the biomass resided in the larger grounds, North Bank and Barnhourie. There was evidence of an increase in the stock on North Bank; both the estimated biomass and biomass density were higher in 2015 than 2013.

In 2015, over 40% of the biomass comprised '0' and 1 group cockles compared to 10% in 2013. Representation of these year classes on the two large banks differed, with much higher '0' group densities at North Bank than at Barnhourie and higher density of one year olds at Barnhourie than North Bank. Densities of '0' group on North Bank and Carsethorn were much higher than on the other grounds. It should be noted that the survey only samples cockles 5 mm and over. It is possible that timing of reproduction, spat settlement and growth rates differ between grounds and that smaller cockles were present but not sampled. Previous studies have, however, shown that '0' group densities are not a reliable indicator of future year class strength, due to variability in first winter mortality which can be extremely high (Chapman *et al*., 1994). The commercial biomass and biomass density estimates (all grounds combined) from the 2015 survey are somewhat lower than those obtained in 2013, but an improvement on 2007 – 2009. The relatively high densities of 1 year old cockles found on Barnhourie in 2015, should these survive and grow to commercial size, indicate some potential for future harvestable stock on this ground. Densities of one and two year olds on Carsethorn Bank and of two years old at Fleet were are also relatively high. The biomass at Wigtown Bay is likely to have been underestimated due to the reduced survey area. Biomass densities at Wigtown have, however, been maintained and sampling indicates a good representation of year classes, characteristic of an 'upholding population', as defined by Ducrotoy *et al*., (1991).

After cockles*, M. balthica* was the most abundant bivalve species in the 2015 survey. This is consistent with findings in previous surveys in which other bivalves were included. The overall biomass estimate for *M. balthica* of 2,060 tonnes in 2015, is

substantially lower than in the 2013 survey (11,551 tonnes) (Stamp *et al*., 2013) and from surveys between 2007 and 2009 when estimates ranged from 4,135 to 15,479 tonnes (Howell *et al*., 2007, 2012a, 2012b). Biomass densities of *M. balthica* in 2015 were also substantially lower than in earlier surveys, suggesting a significant decline in abundance compared to 2013, rather than any effect due to the reduction in survey area. The reasons for this decline are not known. Long term studies in the Wadden Sea (Beukema and Dekker, 2014) provide evidence that annual recruitment in the major bivalve species including *M. balthica* and *C. edule* is most successful in summers following severe winters, whereas failures are most commonly seen after mild winters, the latter being associated with high abundance of shrimps and shore crabs which prey on recently settled bivalve spat. Others studies have highlighted the influence of sediment dynamics on the success of early recruitment and the maintenance of bivalve populations (Bouma *et al*., 2001). The variable representation of older year classes on the different grounds suggests localised influences on recruitment and stock dynamics within relatively small areas.

As indicated above, advice on commercial fishing in the Scottish Solway needs to take into account nature conservation designations including the feeding requirements of shorebird populations within the Solway SPA. The data presented in this report were provided to Scottish Natural Heritage who modelled the shorebird feeding requirements. Outputs from the model, as applied to the grounds in the Inner Solway Firth (all grounds surveyed excluding Fleet and Wigtown) indicated that there was insufficient surplus stock to support a commercial fishery in 2015/ 2016.

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Table 1. Sampling details for the Stratified Random (SR) and Adaptive Surveys (AS) conducted in August 2015. Information is given on the number of stations, number of strata, survey coverage and numbers of *C. edule* sampled on each ground.

Area	Date(s) surveyed	Sampling method	Number of stations	Number of strata	Stratum area (km^2)	Total area (km^2)*	Non zero stations	Number caught	Number measured	Number aged and measured	Number missing length & weight
Arbigland	14.08.15	SR	30	19	0.224	4.04	14	39	38	38	1
Auchencairn Bay	13.08.15	SR	41	21	0.1	2.08	12	29	29	29	0
Barnhourie	11, 15 & 20.08.15	SR & AS	188	73	0.328	23.51	131	1499	1481	1476	17
Carsethorn	12.08.15	SR	54	29	0.129	3.74	44	1055	1031	1031	24
Fleet Bay	16.08.15	SR	27	18	0.36	5.87	14	177	173	173	4
North Bank	10, 14, 17 & 18.08.15	SR	112	58	0.741	42.97	75	917	880	880	36
Orchardton Bay	13.08.15	SR	9	6	0.243	1.18	4	6	6	6	0
Rough Island and Glenisle	13 & 15.08.15	SR	29	19	0.166	2.75	11	70	65	65	5
Wigtown Bay	19.08.15	SR	9	6	0.358	2.15	4	114	114	114	0
Totals			**499**	**249**		**88.29**	**309**	**3906**	**3817**	**3812**	**87**

* The total area takes into account the proportion of the strata available for sampling

Table 2. Abundance (millions), biomass (tonnes) and variance of *C. edule* by age category at Arbigland, Auchencairn Bay, Carsethorn, Fleet Bay, North Bank, Orchardton Bay, Rough Island and Glenisle and Wigtown Bay following the August 2015 stratified random surveys. *NB the total all ages includes individuals which could not be aged.

		Age								
		0	1	2	3	4	5	6	Total all ages*	2+
Arbigland	Abundance (millions)	26.6	7.8	11.8	6.4	2	2.2	0	56.8	22.4
	Abundance variance	32.6	3.7	13	5	0	5	0	72.4	33.1
	Weight (tonnes)	3.5	26.1	87.4	84.4	15.2	42.7	0	259.3	229.7
	Weight variance	0.5	41	686	788.8	0	1820	0	6163.7	5769.5
Auchencairn Bay	Abundance (millions)	4.5	3.9	1	3.5	1.5	0	0	14.4	6
	Abundance variance	4.8	1.9	0.5	2.8	0.8	0	0	17.7	7
	Weight (tonnes)	0.6	14.4	4.4	55.3	39.2	0	0	113.8	98.9
	Weight variance	0.1	26.1	9.7	684	514	0	0	2083.4	1944
Carsethorn	Abundance (millions)	259.9	246.4	134.2	20	6.5	0	0	679.8	160.6
	Abundance variance	4060	2451.2	238	30.4	3.3	0	0	7627.4	339.1
	Weight (tonnes)	50.8	521.9	585.7	156.4	84.4	0	0	1426.9	826.5
	Weight variance	160.4	10423.1	4644	1983.6	526.5	0	0	18201.5	9145.4
Fleet Bay	Abundance (millions)	133.6	21.6	152	21.5	1.8	0	0	340.8	175.3
	Abundance variance	151.2	51.8	925.7	74.2	3.2	0	0	1281.8	1125.5
	Weight (tonnes)	19.3	78	1082.1	151	24.6	0	0	1366.5	1257.7
	Weight variance	3	717.2	50301.5	3683.1	604.5	0	0	69391.9	61450.2

Table 2 continued.

		Age								
		0	1	2	3	4	5	6	Total all ages*	2+
North Bank	Abundance (millions)	2419.4	644.7	266.8	48.2	3.7	0	0	3471.6	318.6
	Abundance variance	423904.3	9087.3	4145.6	260.8	13.7	0	0	498359.6	4612.3
	Weight (tonnes)	357.7	1932.7	1693.8	675.2	48.7	0	0	4854.3	2417.8
	Weight variance	9168.1	81896.2	167518.1	50161.4	2373.6	0	0	486032.9	246448.3
Orchardton Bay	Abundance (millions)	0	1.7	2	1.8	1.3	0	0	6.8	5.1
	Abundance variance	0	0	2	3.3	0	0	0	8.6	8.6
	Weight (tonnes)	0	3.3	22.5	22.3	22.1	0	0	70.2	66.9
	Weight variance	0	0	258.4	498	0	0	0	1181.9	1181.9
Rough Island and Glenisle	Abundance (millions)	47.3	0.8	1.5	4.4	1.5	0.8	0	60.5	8.3
	Abundance variance	42	0.7	1.1	2.7	1.1	0.7	0	124.4	9.3
	Weight (tonnes)	7.9	0.2	7.3	53.5	28.2	14	0	112.1	102.9
	Weight variance	1	0	26.4	401.9	407.4	195.2	0	1726.6	1725.4
Wigtown Bay	Abundance (millions)	14.3	91.2	64.4	23.3	28.6	0	0	221.8	116.3
	Abundance variance	12.8	5386.1	1448.2	131.4	628	0	0	19788.5	4963.2
	Weight (tonnes)	4.1	252	290.6	197.2	322.7	0	0	1066.6	810.5
	Weight variance	0.8	41520.1	29644.3	9348.9	79382.8	0	0	510836.5	269212.1

Table 3. Results of adaptive surveys on Barnhourie for 2015. (A) Abundance (millions), biomass (tonnes) and variance of *C. edule* by age derived from stage 1 of the survey and (B) from stage 1 and 2 combined. *NB the total all ages includes individuals which could not be aged.

(A)

		Age								
		0	1	2	3	4	5	6	*Total all ages	2+
Barnhourie	Abundance (millions)	50.8	797.3	435.6	121.3	29.5	3.3	1.4	1455.8	591.2
	Abundance variance	497.4	30957.2	3647.8	688.5	59.2	5.4	2	55111.3	5875.9
	Weight (tonnes)	16.7	1736.1	1547.4	780.1	285.8	34.4	14	4453.7	2661.7
	Weight variance	49.5	150076.6	47048.7	28661.9	5583.6	591.6	194.8	385949.8	117696.4

(B)

		Age								
		0	1	2	3	4	5	6	*Total all ages	2+
Barnhourie	Abundance (millions)	56.6	944.4	301.1	83.7	27.7	2.1	1.4	1437	416.0
	Abundance variance	509.6	30152.5	1133.5	208.5	76.8	1.8	2	47620.7	1895.4
	Weight (tonnes)	18.5	2103.6	1075.9	540	270.6	21.6	14	4096.2	1922.1
	Weight variance	50.7	149793.5	14591.1	8726.8	7434.3	181.1	194.8	296828.9	47033.7

Table 4. (A) Abundance (millions) and (B) density (number/m^2) by age of *C. edule* on each ground during August 2015 survey. *NB the total all ages includes individuals which could not be aged.

(A)

	Age							
	0	1	2	3	4	5	6	*Total all ages
Arbigland	26.57	7.8	11.79	6.39	1.98	2.24	0	56.77
Auchencairn Bay	4.5	3.94	1	3.5	1.5	0	0	14.44
Barnhourie	56.64	944.37	301.13	83.67	27.67	2.11	1.42	1437.04
Carsethorn	259.94	246.39	134.16	20	6.45	0	0	679.83
Fleet Bay	133.6	21.65	152	21.46	1.8	0	0	340.75
North Bank	2419.36	644.67	266.76	48.16	3.7	0	0	3471.59
Orchardton Bay	0	1.66	2.01	1.81	1.3	0	0	6.78
Rough Island and Glenisle	47.31	0.83	1.51	4.42	1.5	0.82	0	60.55
Wigtown Bay	14.29	91.24	64.42	23.27	28.64	0	0	221.85
All areas	2962.21	1962.55	934.78	212.68	74.54	5.17	1.42	6289.6

(B)

	Age							
	0	1	2	3	4	5	6	*Total all ages
Arbigland	6.58	1.93	2.92	1.58	0.49	0.55	0	14.05
Auchencairn Bay	2.16	1.89	0.48	1.68	0.72	0	0	6.93
Barnhourie	2.41	40.18	12.81	3.56	1.18	0.09	0.06	61.13
Carsethorn	69.48	65.86	35.86	5.35	1.72	0	0	181.72
Fleet Bay	22.76	3.69	25.9	3.66	0.31	0	0	58.06
North Bank	56.3	15	6.21	1.12	0.09	0	0	80.79
Orchardton Bay	0	1.41	1.7	1.53	1.1	0	0	5.75
Rough Island and Glenisle	17.22	0.3	0.55	1.61	0.55	0.3	0	22.03
Wigtown Bay	6.66	42.5	30.01	10.84	13.34	0	0	103.33
All areas	33.55	22.23	10.59	2.41	0.84	0.06	0.02	71.24

Table 5. (A) Biomass (tonnes) and (B) biomass density (tonnes/km^2) by age of *C. edule* on each ground during August 2015 survey. *NB the total all ages includes individuals which could not be aged.

(A)

	Age							
	0	1	2	3	4	5	6	Total* all ages
Arbigland	3.48	26.11	87.37	84.44	15.25	42.66	0	259.31
Auchencairn Bay	0.58	14.39	4.37	55.28	39.21	0	0	113.83
Barnhourie	18.51	2103.6	1075.91	539.96	270.65	21.6	13.96	4096.18
Carsethorn	50.83	521.91	585.66	156.45	84.42	0	0	1426.94
Fleet Bay	19.28	78.04	1082.11	150.96	24.59	0	0	1366.53
North Bank	357.71	1932.68	1693.85	675.24	48.72	0	0	4854.33
Orchardton Bay	0	3.31	22.48	22.32	22.13	0	0	70.23
Rough Island and Glenisle	7.86	0.23	7.26	53.5	28.18	13.97	0	112.1
Wigtown Bay	4.14	251.96	290.62	197.24	322.66	0	0	1066.62
All areas	462.39	4932.23	4849.63	1935.39	855.81	78.23	13.96	13366.07

(B)

	Age							
	0	1	2	3	4	5	6	Total* all ages
Arbigland	0.86	6.46	21.62	20.9	3.77	10.56	0	64.17
Auchencairn Bay	0.28	6.9	2.1	26.53	18.81	0	0	54.62
Barnhourie	0.79	89.49	45.77	22.97	11.51	0.92	0.59	174.26
Carsethorn	13.59	139.51	156.55	41.82	22.57	0	0	381.43
Fleet Bay	3.29	13.3	184.37	25.72	4.19	0	0	232.84
North Bank	8.32	44.98	39.42	15.71	1.13	0	0	112.97
Orchardton Bay	0	2.81	19.05	18.92	18.75	0	0	59.52
Rough Island and Glenisle	2.86	0.08	2.64	19.47	10.25	5.08	0	40.79
Wigtown Bay	1.93	117.36	135.37	91.87	150.29	0	0	496.81
All areas	5.24	55.87	54.93	21.92	9.69	0.89	0.16	151.4

Table 6. Comparison of 2013 and 2015 survey results. Estimates of area surveyed (km^2) *C. edule* biomass (tonnes) and biomass density (tonnes/km^2) in each year are shown rounded to one decimal place. NS = not surveyed.

Ground	2013			2015		
	tonnes	km^2	tonnes/km^2	tonnes	km^2	tonnes/km^2
Arbigland	NS	NS	NS	259.3	4.0	64.2
Auchencairn	407.4	3.2	128.5	113.8	2.1	54.6
Barnhourie	4962.0	20.9	237.3	4096.2	23.5	174.3
Carsethorn	431.1	5.8	74.8	1426.9	3.7	381.4
Fleet Bay	103.1	4.9	21.1	1366.5	5.9	232.8
Glenisle	49.8	0.8	65.2	112.1	2.8	40.8
Rough Island	296.2	2.6	113.2			
North Bank	1932.4	50.0	38.7	4854.3	43.0	113.0
Orchardton Bay	76.6	1.0	73.7	70.2	1.2	59.5
Wigtown Bay	5983.4	13.1	458.0	1066.6	2.2	496.8
Total	14242.1	102.2	139.4	13366.1	88.3	151.4

Table 7. Comparative summary of Solway Firth survey results 1990-2015. (A) abundance densities and (B) biomass and biomass density of under-aged and commercial-aged *C. edule.* Ages 2 and over (2+) have been used as a proxy for commercial sized individuals.

(A) Abundance density

Survey Year	Total Survey Area (km^2)	Cockle density (no per m^2)		
		Under-aged	Commercial aged	Total all ages
1990 (December)	64.52	15.36	41.18	56.42
1991 (December)	54.00	26.11	7.11	33.22
1992 (December)	*61.99*	*47.69*	*5.03*	*52.72*
1993 (May)*	51.63	9.82	5.86	15.68
1994 (April)*	47.01	1.43	4.92	6.35
1995 (April)*	102.03	4.96	1.98	6.94
1996 (April)*	100.62	15.23	2.43	17.67
1997 (April)*	121.77	21.28	5.62	26.90
1998 (April)*	116.21	11.64	15.44	27.08
1999 (April)*	111.28	20.35	9.84	30.19
2000 (May)*	133.77	7.19	10.18	17.37
2001 (May)*	109.73	4.64	5.61	10.25
2002 (April)*	117.16	127.49	5.69	133.18
2003 (May)*	118.52	5.87	39.55	45.42
2004 (May)*	116.40	11.00	29.20	40.20
2005 (May)*	119.73	5.70	13.80	19.50
2006 (April)*	121.35	6.97	7.43	14.39
2007 (August)	113.55	124.37	3.43	127.80
2008 (August)	88.77	25.16	3.27	28.43
2009 (August)	92.93	46.98	11.72	58.70
2013 (July)	102.17	8.25	18.45	26.70
2015 (August)	88.29	55.78	13.92	**71.24

*At the time of these surveys “under aged” *C. edule* had one growth ring but had not reached commercial size, and the “0” age category of the year had not yet settled.

**The total all ages for 2015 includes individuals which could not be aged.

(B) Biomass

Survey Year	Biomass (tonnes per km^2)			Biomass (tonnes)		
	Under-aged	Commercial aged	Total all ages	Under-aged	Commercial aged	Total
1990	8.8	187.9	196.7	571	12123	12694
1991	10.4	46.3	56.7	563	2501	3064
1992	29.3	31.9	61.2	1815	1979	3794
1993*	3.8	36.8	40.6	196	1902	2098
1994*	0.9	40.2	41.1	41	1888	1929
1995*	3.2	21.6	24.8	323	2199	2522
1996*	10.9	18.0	28.9	1092	1811	2903
1997*	10.4	41.8	52.2	1263	5094	6357
1998*	12.1	114.6	126.7	1401	13318	14721
1999*	17.4	102.2	119.6	1940	11372	13312
2000*	7.9	94.3	102.2	1062	12610	13672
2001*	4.3	54.6	58.9	476	5991	6467
2002*	70.2	50.4	120.7	8228	5908	14136
2003*	7.4	278.8	286.2	876	33049	33926
2004*	11.7	279.3	291.0	1357	32515	33872
2005*	5.9	155.3	161.2	706	18598	19304
2006*	6.0	63.8	69.8	729	7740	8469
2007	68.3	39.4	107.7	7751	4474	12225
2008	19.2	23.1	42.3	1707	2050	3757
2009	33.0	72.5	105.5	3064	6735	9799
2013	14.5	124.9	139.4	1486	12756	14242
2015	61.1	87.6	**151.4	5395	7733	**13366

* At the time of these surveys “under aged” *C. edule* had one growth ring but had not reached commercial size, and the “0” age category of the year had not yet settled

** the total all ages for 2015 includes individuals which could not be aged.

Table 8. Sampling details for the Stratified Random (SR) and Adaptive Surveys (AS) conducted in August 2015. Information is given on the number of stations, number of strata, survey coverage and numbers of *M. balthica* sampled on each ground.

Area	Date(s) surveyed	Sampling method	Number of stations	Number of strata	Stratum area (km^2)	Total area (km^2)*	Non zero stations	Number caught	Number measured	Number missing length & weight
Arbigland	14.08.15	SR	30	19	0.224	4.04	15	38	38	0
Auchencairn Bay	13.08.15	SR	41	21	0.1	2.08	3	5	5	0
Barnhourie	11/15/20.08.15	SR & AS	188	73	0.328	23.51	101	737	728	9
Carsethorn	12.08.15	SR	54	29	0.129	3.74	47	275	272	3
Fleet Bay	16.08.15	SR	27	18	0.36	5.87	7	31	27	4
North Bank	10/14/17/18.08.15	SR	112	58	0.741	42.97	90	1015	998	17
Orchardton Bay	13.08.15	SR	9	6	0.243	1.18	2	4	4	0
Rough Island and Glenisle	13/15.08.15	SR	29	19	0.166	2.75	8	53	51	2
Wigtown Bay	19.08.15	SR	9	6	0.358	2.15	4	6	6	0
Totals			499	249		88.29	277	2164	2129	35

Table 9. Total abundance (millions), biomass (tonnes) and variance of *M. balthica*, for measured categories > 5 mm on each ground during the 2015 surveys.

	Abundance (millions)	Abundance variance	Biomass (tonnes)	Biomass Variance
Arbigland	47.51	137.82	20.66	33.28
Auchencairn Bay	2.5	2.75	0.81	0.28
Barnhourie	959.84	13746.27	347.59	2697.03
Carsethorn	194.79	192.2	74.03	38.46
Fleet Bay	61.98	97.16	23.27	34.67
North Bank	3734.64	77447.88	1572.91	13337.82
Orchardton Bay	8.2	0.82	1.59	0.07
Rough Island and Glenisle	46.70	735.15	6.42	4.05
Wigtown Bay	16.09	16.02	12.95	14.8

Table 10. Total abundance density (number/m^2) and biomass density (tonne/km^2) estimates for measured categories of *M. balthica* on grounds surveyed in 2015.

	Abundance density (number/m^2)	Biomass density (tonnes/km^2)
Arbigland	11.76	5.11
Auchencairn Bay	1.20	0.39
Barnhourie	40.83	14.78
Carsethorn	52.09	19.80
Fleet Bay	10.56	3.97
North Bank	86.91	36.61
Orchardton Bay	6.95	1.35
Rough Island and Glenisle	16.98	2.33
Wigtown Bay	7.48	6.02

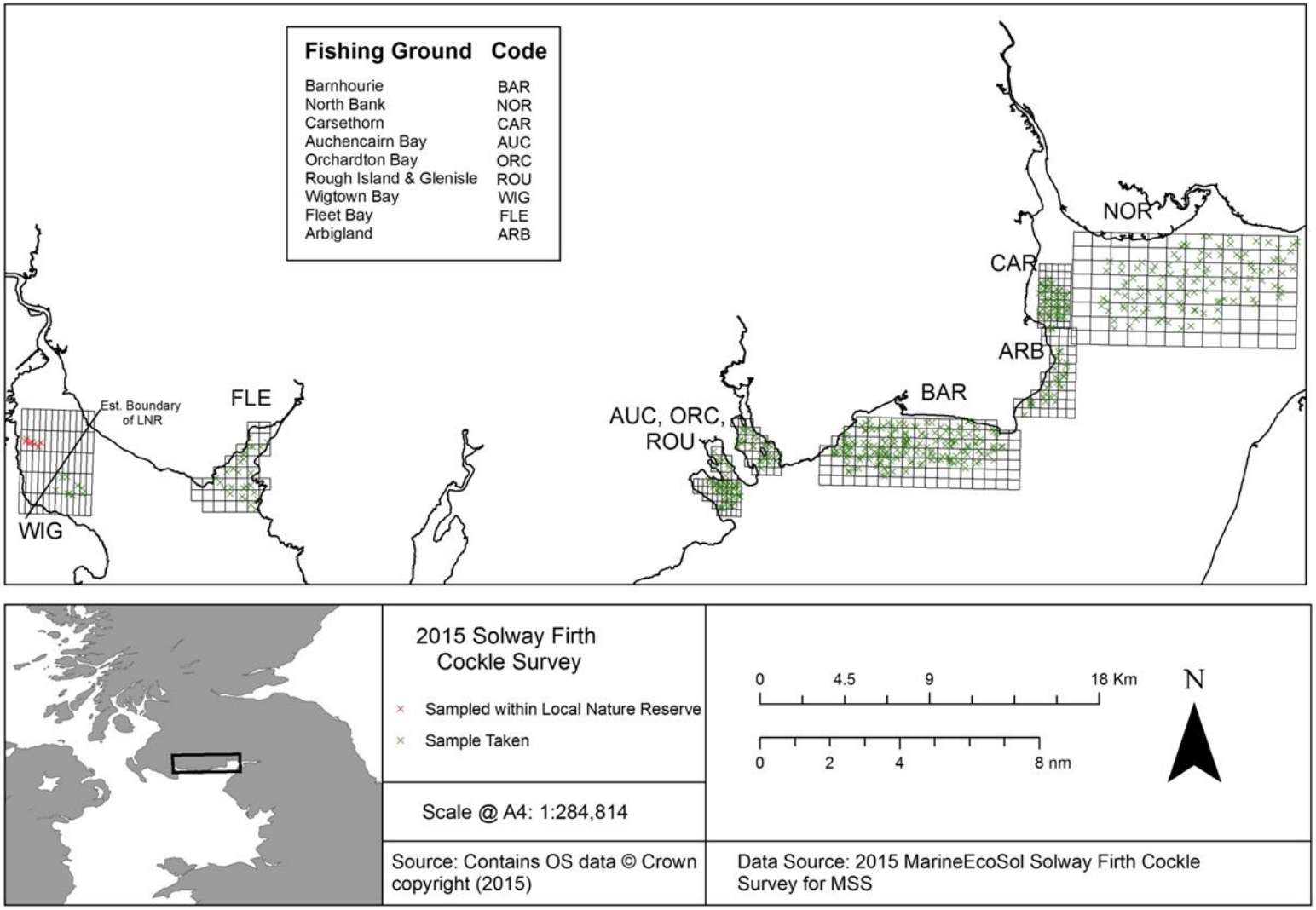

Figure 1. Cockle grounds included within the survey brief (boxes) and all stations sampled (x) during the 2015 survey.

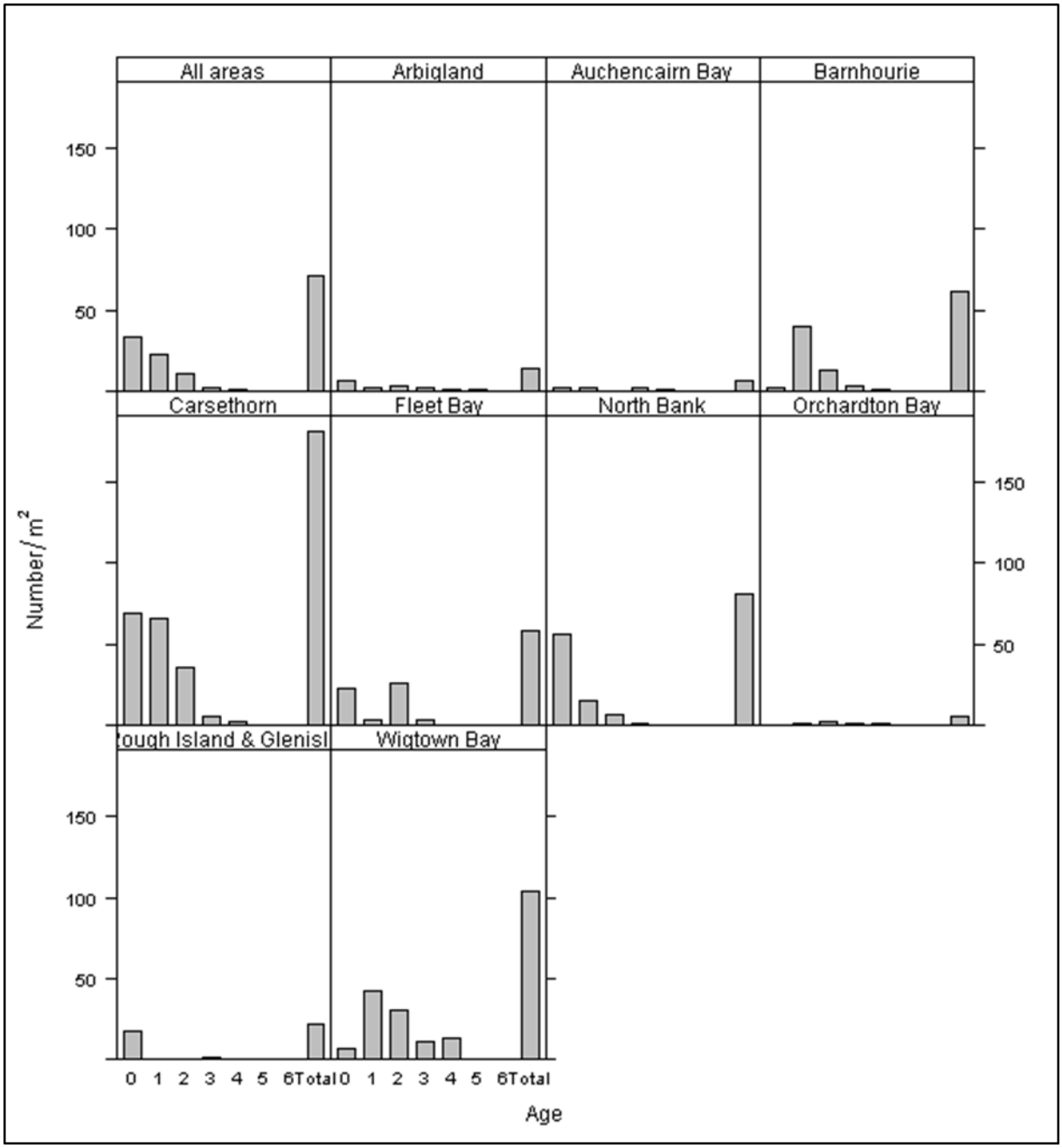

Figure 2. Density (number/m^2) of *C. edule* on grounds surveyed in 2015 survey, by age category and for all ages combined. Note. The 'total' category includes individuals which could not be aged.

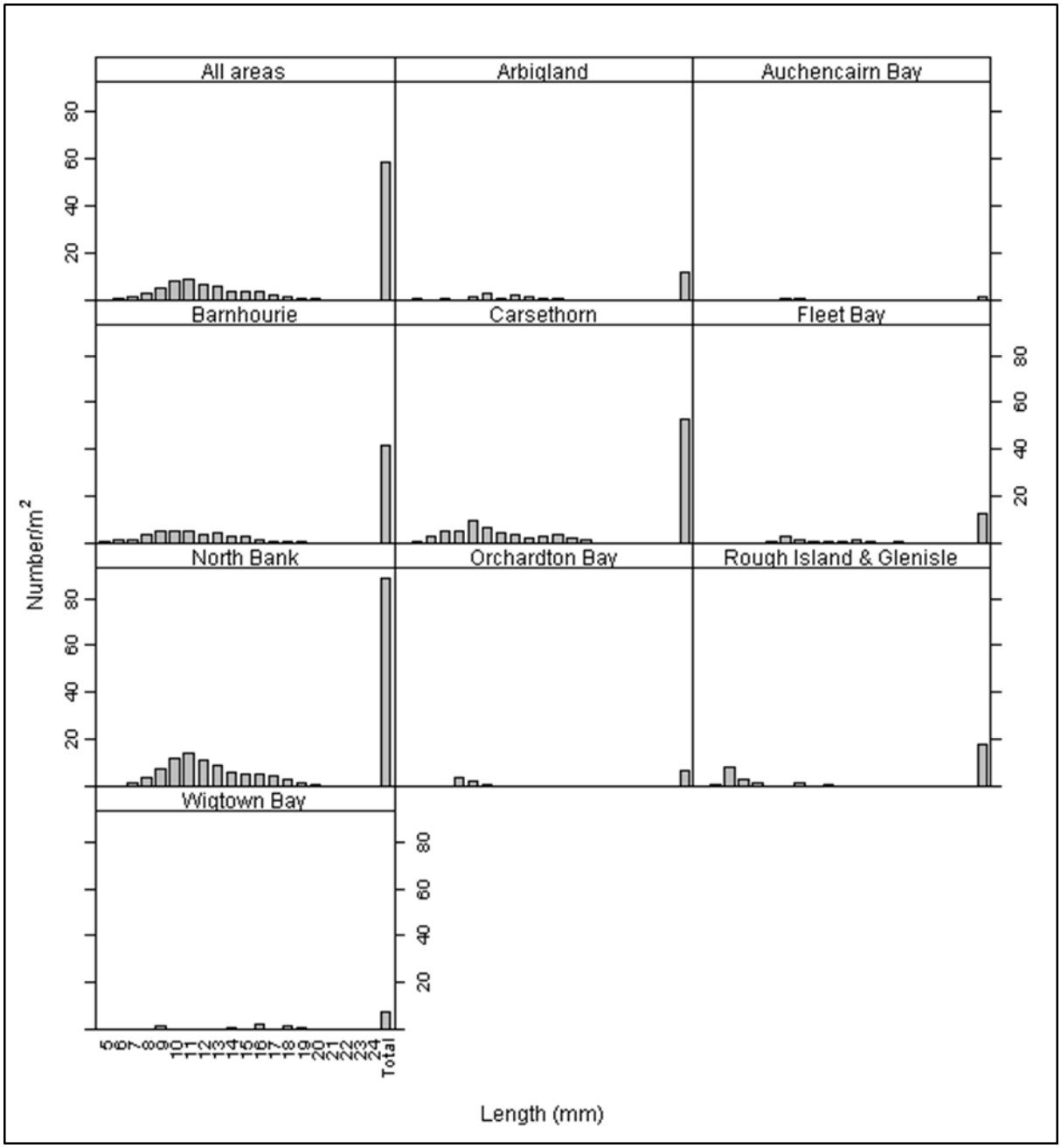

Figure 3. Density (number/m^2) of *M. balthica* on grounds surveyed in 2015 survey, by length category and for all lengths combined. Note. The 'total' category includes individuals which could not be accurately measured.

Appendix 1

Details of additional sampling stations used in phase 2 sampling design at Barnhourie, including coordinates (latitudes and longitudes), G-Statistic, Strata ID and Sample ID.

Extra Station Number	Located In Stratum	Sample.ID	G Statistic	Longitude	Latitude
1	54	BAR22_C	2.77	54.862371	-3.703928
2	72	BAR22_D	2.55	54.868021	-3.682496
3	51	BAR22_E	1.95	54.861888	-3.731496
4	50	BAR36_C	1.77	54.861334	-3.742187
5	76	BAR38_C	1.60	54.867165	-3.643526
6	54	BAR44_C	1.38	54.859849	-3.698898
7	72	BAR44_D	1.28	54.867735	-3.686461
8	67	BAR44_E	1.13	54.866346	-3.735966
9	22	BAR44_F	1.13	54.854346	-3.699284
10	51	BAR50_C	0.98	54.85928	-3.731141
11	50	BAR50_D	0.89	54.863379	-3.737719
12	44	BAR50_E	0.87	54.857381	-3.648315
13	54	BAR50_F	0.83	54.860317	-3.701584
14	76	BAR51_C	0.80	54.867631	-3.646959
15	44	BAR51_D	0.80	54.85774	-3.641412
16	72	BAR51_E	0.77	54.864227	-3.680224
17	58	BAR51_F	0.75	54.859969	-3.662419
18	70	BAR51_G	0.64	54.865876	-3.701919
19	53	BAR53_C	0.64	54.859363	-3.713983
20	51	BAR53_D	0.59	54.863353	-3.729923
21	67	BAR54_C	0.57	54.867536	-3.736461
22	22	BAR54_D	0.57	54.850407	-3.704001

Extra Station Number	Located In Stratum	Sample.ID	G Statistic	Longitude	Latitude
23	54	BAR54_E	0.55	54.859214	-3.701643
24	55	BAR54_F	0.54	54.859576	-3.692442
25	50	BAR54_G	0.53	54.859815	-3.743488
26	72	BAR54_H	0.51	54.864187	-3.685583
27	76	BAR55_C	0.48	54.866503	-3.645938
28	44	BAR58_C	0.48	54.857617	-3.648003
29	54	BAR58_D	0.40	54.860216	-3.705689
30	51	BAR62_C	0.39	54.863602	-3.731906
31	58	BAR67_C	0.37	54.862798	-3.663326
32	72	BAR67_D	0.36	54.866598	-3.68378
33	78	BAR67_E	0.36	54.86764	-3.62142
34	50	BAR70_C	0.35	54.862693	-3.743752
35	67	BAR70_D	0.34	54.864075	-3.733964
36	22	BAR71_C	0.34	54.851604	-3.699243
37	76	BAR72_C	0.32	54.867943	-3.646606
38	44	BAR72_D	0.32	54.856919	-3.644723
39	70	BAR72_E	0.32	54.868444	-3.698351
40	53	BAR72_F	0.32	54.863653	-3.715835
41	54	BAR72_G	0.30	54.861804	-3.700185
42	36	BAR72_H	0.28	54.859004	-3.721041
43	38	BAR76_C	0.28	54.856012	-3.705516
44	62	BAR76_D	0.28	54.861658	-3.621956
45	71	BAR76_E	0.28	54.865746	-3.69446
46	51	BAR76_F	0.28	54.860148	-3.735331
47	72	BAR78_C	0.27	54.866055	-3.685783

Appendix 2

Cockle (*Cersatoderma edule)* biomass (tonnes) by mm length class on each of the grounds surveyed in 2015.

Length (mm)	Arbigland	Auchencairn Bay	Barhourie	Carsethorn	Fleet Bay	North Bank	Orchardton Bay	Rough Island and Glenisle	Wigtown Bay
5	0	0	0	4.33	0	3.9	0	0	0
6	0.14	0	0.5	8.96	2.26	23.11	0	0.68	0
7	2.12	0.52	4.66	18.92	11.59	135.33	0	3.82	0.45
8	0.92	0.07	6.5	14.28	3.79	134.73	0	1.67	0.42
9	0.15	0	12.13	7.65	0.67	40.36	0	1.2	0.83
10	0	0	35.05	15.51	10.24	17.49	0	0.58	0.88
11	0	0	62.48	23.69	0.26	4.99	0	0.14	0
12	0	0	88.55	22.18	0	22.78	0	0	0
13	0	0	165.54	41.9	0	11.22	0	0	0
14	0	1.91	202.36	69.99	0	12.49	0	0	9.49
15	0	0	278.89	80.53	0	87.52	0	0	9.76
16	0	1.72	315.5	94.28	5.76	122.94	0	0	6.27
17	0	3.6	377.91	67.31	6.13	168.23	3.31	0	9.68
18	0	0	337.9	91.33	0	234.08	0	0	4.69
19	0	0	276.87	124.5	12.7	154.03	0	3.48	59.66
20	18.68	1.82	276.63	88.7	55.3	232.57	0	0	58.11
21	3.7	3.36	242.58	119.86	59.34	337.45	0	0	70.27
22	3.74	0	269.47	111.23	104.59	410.24	0	8.88	72.89
23	0	0	208.26	54.7	149.15	472.1	0	0	65.97
24	15.76	2.42	167.25	75.77	87.61	467.12	0	0	55.82
25	16.2	9.85	117.19	19.85	201.22	196.14	0	0	29.9
26	0	0	147.98	43.82	185.58	233.5	0	0	102.48
27	31.67	2.08	46.73	9.99	165.23	190.45	0	3.78	40.96
28	13.56	0	81.26	37.7	102.37	141.86	9.53	0	65.29
29	38.99	7.7	101.67	55.84	77.56	47.49	0	0	93.78
30	14.53	0	104.28	22.48	62.99	48.55	11.02	9.08	30.73
31	0	0	49.11	6.08	26.05	124.13	11.3	22.75	95.36
32	30.31	12.1	47.08	19.86	24.59	174.51	12.95	0	121.67
33	0	15.59	4.25	10.97	0	287.42	0	0	61.27
34	26.04	7.81	0	18.64	0	0	22.13	13.97	0
35	0	8.06	17.79	0	0	52.96	0	24.63	0
36	42.66	8.1	0	17.9	0	0	0	0	0
37	0	0	0	0	0	54.68	0	16.35	0
40	0	13.32	0	0	0	0	0	0	0
41	0	13.79	0	0	0	0	0	0	0

Appendix 3

Macoma balthica biomass (tonnes) by mm length class on each of the grounds surveyed in 2015.

Length (mm)	Arbigland	Auchencairn Bay	Barhourie	Carsethorn	Fleet Bay	North Bank	Orchardton Bay	Rough Island and Glenisle	Wigtown Bay
5	0	0	0.45	0.02	0	0	0	0	0
6	0.1	0	1.42	0.13	0	0.19	0	0	0
7	0	0	2.38	0.72	0	3.24	0	0.39	0
8	0.39	0	10.78	2.33	0	15.96	0	0.48	0
9	0.18	0	16.08	3.05	0	49	0.79	0.58	0.58
10	0.98	0	25.38	7.98	0.8	109.68	0.54	0	0
11	3.27	0.44	29.45	7.87	1.05	157.09	0.26	0.24	0
12	1.25	0.37	29.02	6.01	2.52	147.78	0	1.37	0
13	4.05	0	36.83	6.96	1.69	166.82	0	0.32	0
14	2.6	0	30.59	4.12	2.48	148.31	0	1.35	1.04
15	2.38	0	41.28	7.75	1.91	136.24	0	0	0
16	2.86	0	28.61	11.53	4.41	163.96	0	0	4.56
17	1.09	0	20.68	7.19	3.42	150.09	0	1.68	0
18	0	0	25.41	5.39	0	114.95	0	0	4.27
19	1.5	0	26.28	1.8	5	82.61	0	0	2.49
20	0	0	10.77	0	0	65.8	0	0	0
21	0	0	12.18	1.2	0	27.52	0	0	0
22	0	0	0	0	0	23.59	0	0	0
24	0	0	0	0	0	10.09	0	0	0