Development of a probability-based sampling design for landings of Scottish shellfish

Tanja Miethe, Alastair Pout and Liz Clarke
Marine Scotland Science, Marine Laboratory, PO Box 101, Victoria Road 375, AB11 9DB Aberdeen, UK, Email: t.miethe@marlab.ac.uk, Phone: +44 1224 2956 84

We present a framework to select a statistically-sound sampling strategy for commercial fisheries landings using a case study of Scottish stocks of *Nephrops norvegicus*. We simulation tested different stratification designs and found that the design with the best performance, in terms of statistical properties and coverage, is based on grouping harbours with the majority of landings from the same *Nephrops* functional units. This design also ensures a high degree of evenness in samples across functional units. The framework is now being applied to other data-limited Scottish shellfish stocks such as brown crabs and lobsters.

Introduction

Shellfish are often sedentary, and many spatially discrete stocks may exist, which are assessed separately. *Nephrops* is exploited inshore as well as offshore, and a number of functional units are defined. Landings from functional units may occur into many different harbours. Sampling designs need to take this into account. To improve the current ad-hoc onshore sampling scheme of commercial *Nephrops* landings, we developed and simulation-tested stratified sampling designs using recent commercial logbook data. It was considered important to ensure even sampling of the functional units.

Materials and Methods

Table 1. Landings (in tonnes) per functional unit of selected harbours which can potentially be sampled. Functional units: Firth of Forth FF, Fladen, FL, Moray Firth MF, Clyde CL, North Minch NM, South Minch SM. Cells with a high proportion of landings for that harbour/function unit combination are highlighted in red, other medium proportions in pink.

harbour	FF	FL	MF	CL	NM	SM	Other
Eyemouth	698	2	0	0	0	0	178*
Pittenweem	928	0	0	0	0	4	2
Peterhead	26	1172	18	0	0	0	349*
Fraserburgh	36	2934	868	0	62	20	154
Burghead	0	0	151	0	0	0	2
Buckie	0	0	92	0	0	0	3
Campbeltown	0	0	0	1549	1	9	32
Troon/Saltcoats	0	0	0	1650	0	6	21
Lochinver	0	0	0	0	478	15	0
Stornoway	0	0	0	0	805	7	2
Ullapool	0	0	1	0	596	40	0
Mallaig	0	1	3	3	71	1258	12
Oban	1	0	0	20	2	560	24
Rest	662	41	69	1812	1212	1187	191
Total	2351	4150	1202	5033	3226	3106	971

* mainly from 40E8, 39E8 (Eyemouth), 42F0 (Peterhead)

The on-shore sampling process was simulated in a stratified two-stage-clustered sampling design using logbook data for *Nephrops* landings of Scottish and UK vessels into Scotland in 2014. The unique date-site clusters (all fishing trips per day and landings site) were used as the primary sampling units, from which a maximum of three fishing trips could be drawn. To limit the number of potential sampling sites, a list of important harbours was compiled (out of 95 in 2014), which represent at least 60% of landings from each functional unit in 2011-2014. Since samples from Fraserburgh would mainly originate from Fladen (FL), Burghead and Buckie were added to the list for representation of the Moray Firth (MF) in samples (Table 1). The fishing trips landing into these harbours then comprised the population to be sampled. We ran 500 sampling simulations with equal sampling effort per stratum. Per simulation 100 day-site events were selected. (This approximates the 133 day-site events actually sampled in 2014). The estimates of landed weight, standard errors, bias, design effect were then averaged across the 500 simulations. Sampling evenness across units was calculated analogous to the Pielou's evenness index. We compared the results for 4 designs: simple random sampling of fishing trips, the unstratified two-stage clustered design, a simple geographical

stratification design with four strata (Str.4, Figure 1) and a design based on the origin of landings per functional unit (Str.6, Figure 1, Table 1). To balance sampling units, Peterhead, Buckie and Burghead constitute a stratum, while Fraserburgh remains separate stratum due to its high number of trips and large vessel sizes.

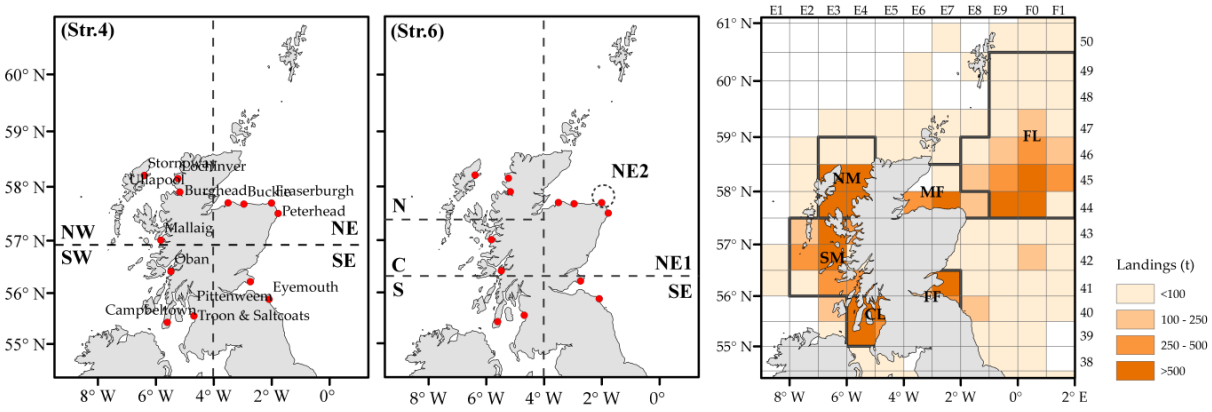

Figure 1. Stratification designs: four strata str.4 (left panel), 13 selected Scottish harbours in red. Six strata str6 (middle panel). Strata: NW northwest, SW southwest, SE southeast, NE northeast and N north, C central, S south, NE1 northeast 1, NE2 northeast 2. Actual total landings (tonnes) per rectangle in 2014 (right panel).

Results and Discussion

The stratification design consisting of six strata, representing the functional units, performed best. With this design, standard errors and bias were low, comparable to simple random sampling (Table 2). In addition, in the six strata design sufficient samples were obtained (on average) for each of the functional units (Figure 2).

Table 2. Relative standard error and bias of the estimates over 500 simulations. True value: 14865 tonnes (only selected harbours).

	design	mean estimate	SE of mean estimate	meanSE of estimate	meanSE/ estimate	Rel. bias	mean design effect	sampling evenness
Simple random		14888	1498	1544	0.10	0.002	1	0.95
2 st. clust.	unstrat	14936	2173	2201	0.15	0.005	2.5	0.98
2 st. clust.	Str.4	14915	2199	2213	0.15	0.003	2.6	0.97
2 st. clust.	Str.6	14917	1960	1826	0.12	0.003	1.7	1.00

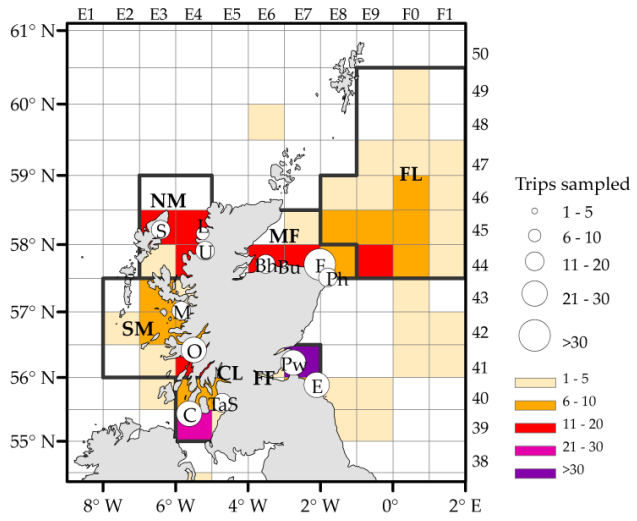

Figure 2 Mean number of trips sampled per harbour and rectangle (500 simulations).

In conclusion, a stratified sampling design based on the structure of functional units works well. The sampling only at selected sites can deliver sufficient coverage of the functional units. As a first proxy we estimated landed weight from sampling. To deliver representative estimates for numbers at length of *Nephrops*, it is a further challenge to sufficiently cover gear types with landings of different length distributions (trawl, creels). This can be achieved by identifying additional important creeling harbours and will be the next stage in the development of the sampling scheme. For other Scottish crustacean stocks the list of potential sampling sites is longer due to higher number of potential landing sites and number of assessment units, but the method works in the same way to achieve a statistically-sound sampling design.