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Dredge survey of sea cucumbers in SCC 3, 2017

New Zealand Fisheries Assessment Report 2017/53

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ISSN 1179-5352 (online)
ISBN 978-1-77665-688-2 (online)

October 2017

New Zealand Government

Growing and Protecting New Zealand

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Tuck, I.D.; Williams, J.R.; Fenwick, M.; Roberts, C.L. (2017). Dredge survey of sea cucumbers in SCC 3, 2017.

***New Zealand Fisheries Assessment Report 2017/53.* 23 p.**

A dredge survey of sea cucumbers (SCC), targeting *Australostichopus mollis* (Echinodermata: Holothuroidea), was conducted in May 2017 in SCC 3, off the north Canterbury coast. Catches of SCC as bycatch of trawl fisheries have exceeded the Total Allowable Commercial Catch (TACC) in this area in recent years. The objective of the survey was to estimate sea cucumber biomass within key areas of SCC 3, to inform fisheries management on sustainable harvest limits. A greenweight to split-weight conversion relationship was also estimated on the basis of catches aggregated to the station level. The survey extent was informed by trawl survey bycatch, fisher knowledge, MPI observer reports and MBIE/MPI-funded habitat survey work, and covered a depth range of 60–120 m, and an area of 3816 km^2. The survey was stratified by depth and latitude, with priority given to the deeper and northern area, where existing data suggested that SCC catch rates would be higher. Raising survey catches to the area covered by the survey provided a total population abundance estimate of 23.8 million SCC (16% CV), with a green weight of 3207 tonnes (13% CV) and a split weight of 1329 tonnes (14% CV). Considering only SCC with a split weight of 63 g or greater (on the basis of a previously estimated marketable SCC selectivity curve) led to a commercial SCC biomass of 619 tonnes (17% CV). Estimating the biomass with non-parametric resampling of SCC within stations, and stations within strata, did not markedly change the estimates: total split-weight biomass was 1326 tonnes (95%CI = 1005 – 1700 t), and 63 g or greater split-weight biomass was 622 tonnes (95%CI = 446 – 837 t). These estimates may be conservative because they assume 100% dredge efficiency. The TACC for SCC 3 is currently 2 t, but landings have consistently exceeded this in recent years. Average SCC 3 landings (since 2011–12) represent 1.2% of the lower 95% CI of estimated commercial SCC biomass for the survey area. Given the large size of the SCC 3 stock area, it was not possible to estimate the biomass at the stock-wide level within this project. Yield estimation and assessment methods for sea cucumbers, and recommendations for longer term monitoring and biological studies, are discussed.

1. INTRODUCTION

1.1 Overview

Sea cucumbers (Echinodermata: Holothuroidea) support relatively low volume, but high-value fisheries worldwide, and small developing fisheries in New Zealand. The only sea cucumber species of commercial value in New Zealand is *Australostichopus mollis* (formerly *Stichopus mollis*), which is fished in a number of areas around the country, and is managed by management area (Figure 1) within the Quota Management System (QMS).

Nominal low TACC limits were set when SCC was introduced into the QMS in 2004 (reflecting the limited information on stocks available), and these have not been updated. Catch limits are currently being met or exceeded in sea cucumber stocks SCC 1B, 3, 7A and 7B, which, with the exception of SCC 3, have until recently been from breath hold diving. Catches in SCC 3 are largely as a bycatch from trawl fisheries, although anecdotal reports from the fishing industry suggest the potential for a targeted SCC fishery.

In this project, we conducted a dredge survey to estimate sea cucumber biomass in key fishery areas of SCC 3 to inform fisheries management on sustainable harvest limits. This is the fundamental information needed to inform appropriate harvest strategies, potential changes in TACC limits or other regulatory controls before they are able to enter the self-sustaining model of cost recovered research. The project was conducted as part of MPI's work in *Increasing the research capacity of developing fisheries*. Further details of the SCC fishery, and the difficulties faced by developing fisheries in provision of robust scientific knowledge to support management are discussed in Williams et al. (2016).

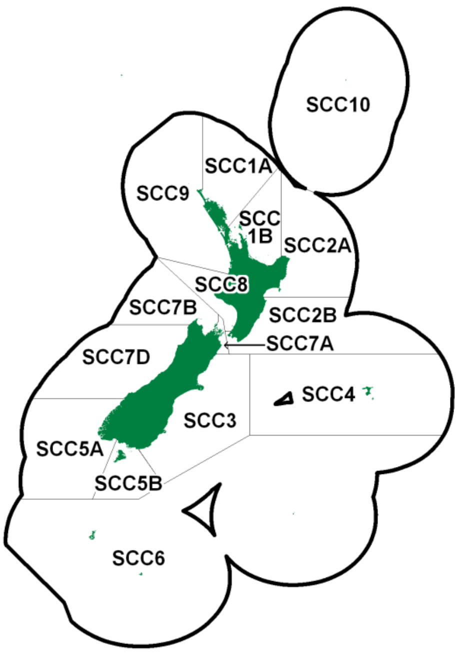

Figure 1: Sea cucumber management areas.

1.2 Objectives

The Overall Objective of this project was to ‘provide stock assessment information that will enable accelerated development of a small-scale inshore shellfish species with potential for growth’. The Specific Objective was to: ‘provide biomass estimates of sea cucumber (SCC) to inform fisheries management on sustainable harvest limits’.

2. METHODS

2.1 Survey locations

The survey area (sample extent), situated offshore from Pegasus Bay, was delimited by a line at 43°00.00’ S latitude in the north and 43°55.00’ S in the south (in line with the southern part of Banks Peninsula), and by the 60 m and 120 m depth contours. The extent was stratified by depth into three depth bands (60–80 m, 80–100 m, and 100–120 m), and divided into two regions, north and south, by a line at latitude 43°16.00’ S which corresponds with a natural geographical break in the coastal shelf formed by a deep-water canyon system. Examination of existing data suggests that this depth range accounts for most of the catch in the region. This resulted in six strata for the survey (Figure 2).

The extent was determined based on knowledge of sea cucumber abundance from commercial fishers (C. Jarman and T. Thredwell, pers. comm.), from analysis of NIWA trawl survey and recent MPI inshore observer data (Figure 3; full data for SCC 3 region shown in Appendix), and from data collected during a NIWA survey of biogenic habitats (Jones et al. 2016) (Figure 4). Strata 2 and 3 encompass the area designated as the main grounds where sea cucumbers have been caught as bycatch in trawl fisheries (C. Jarman, pers. comm.), although sea cucumbers are reported to have been caught as bycatch across the whole survey area (T. Thredwell, pers. comm). The bottom type in the survey area is predominantly soft mud, which sea cucumbers are reported to be associated with, whereas south of Banks Peninsula the bottom is hard, gravelly sand (T. Thredwell, pers. comm). Areas where bycatch of tubeworms was expected are shown in Figure 5. Areas potentially unsuitable for dredge sampling due to the presence of foul ground are shown in Figure 6 (from Jones et al. 2016).

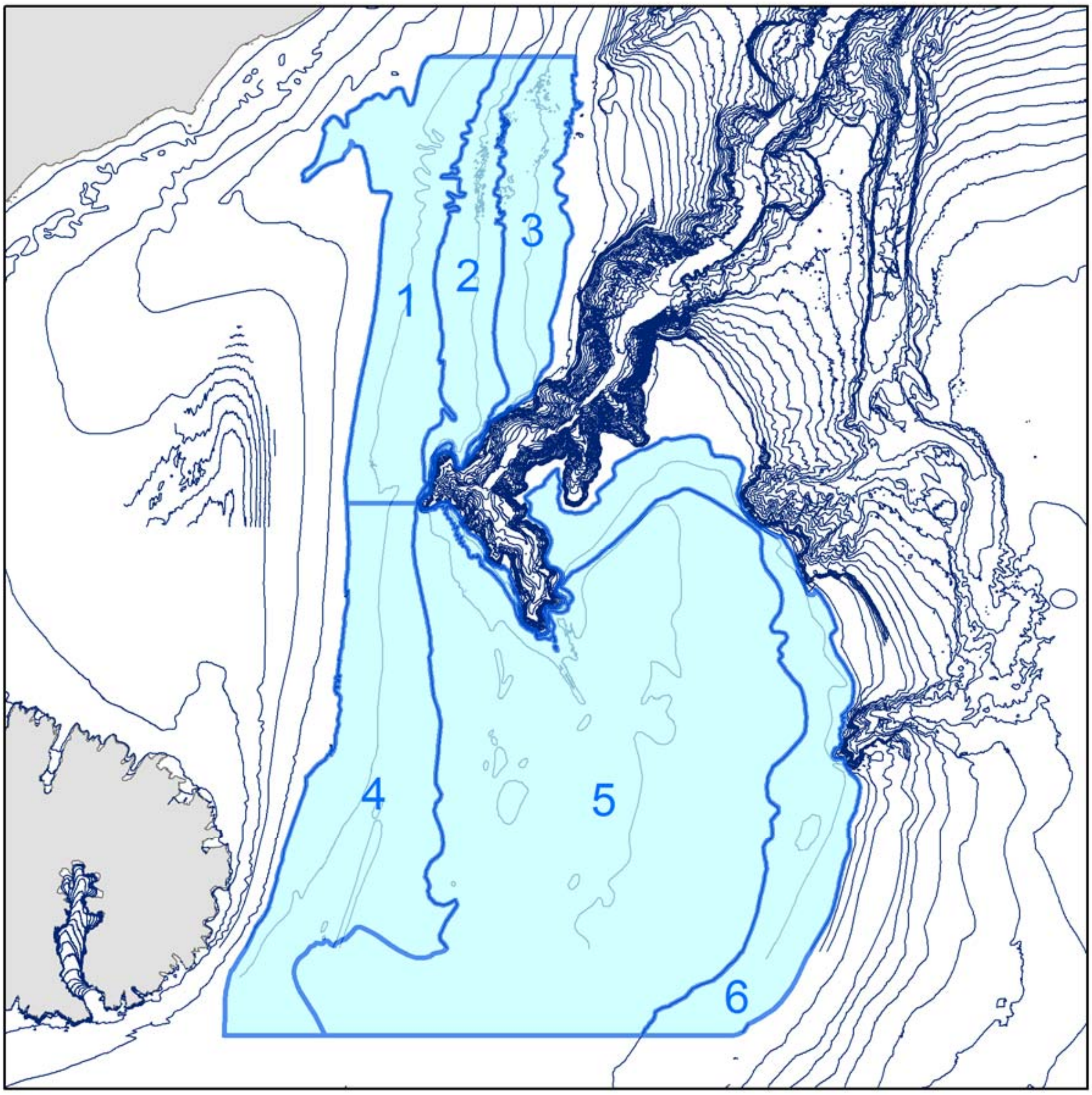

Figure 2: Stratification for the SCC 3 dredge survey, 2017. The survey extent was from 43°00.00’ S in the north to 43°55.00’ S in the south (in line with the southern part of Banks Peninsula), and from 60–120 m depth. The extent was divided into two regions (north, strata 1–3; and south, strata 4–6) at latitude 43°16.00’ S, and also stratified by depth (60–80m, 80–100m and 100–120m). Bathymetry is shown as 10-m depth contour lines.

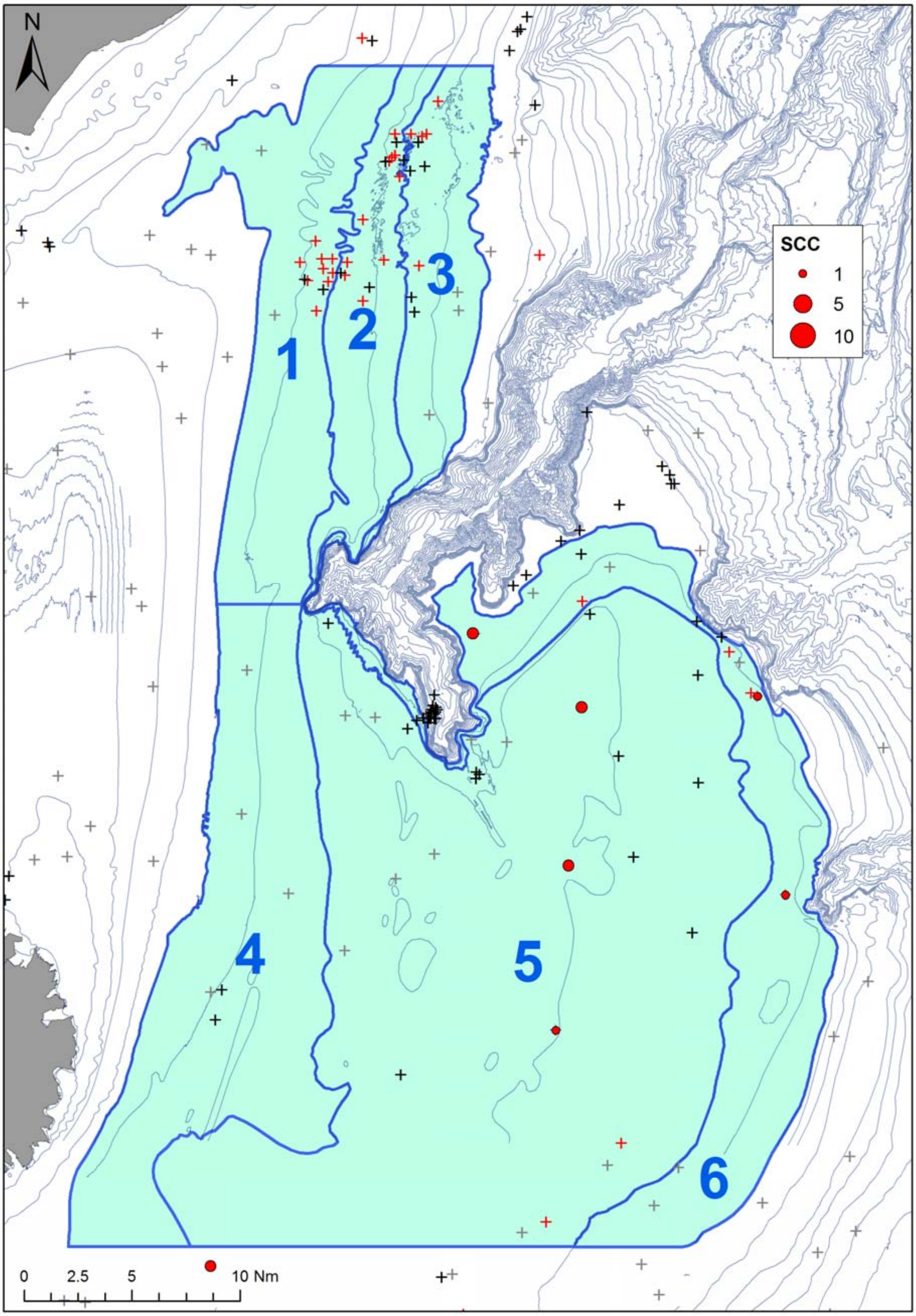

Figure 3: Survey strata in relation to prior information on sea cucumber abundance. The red circles reflect trawl survey catch (kg per tow), red crosses reflect SCC catch recorded by MPI observers on recent inshore trips, and grey and black crosses reflect trawl survey and observer records with no SCC catch.

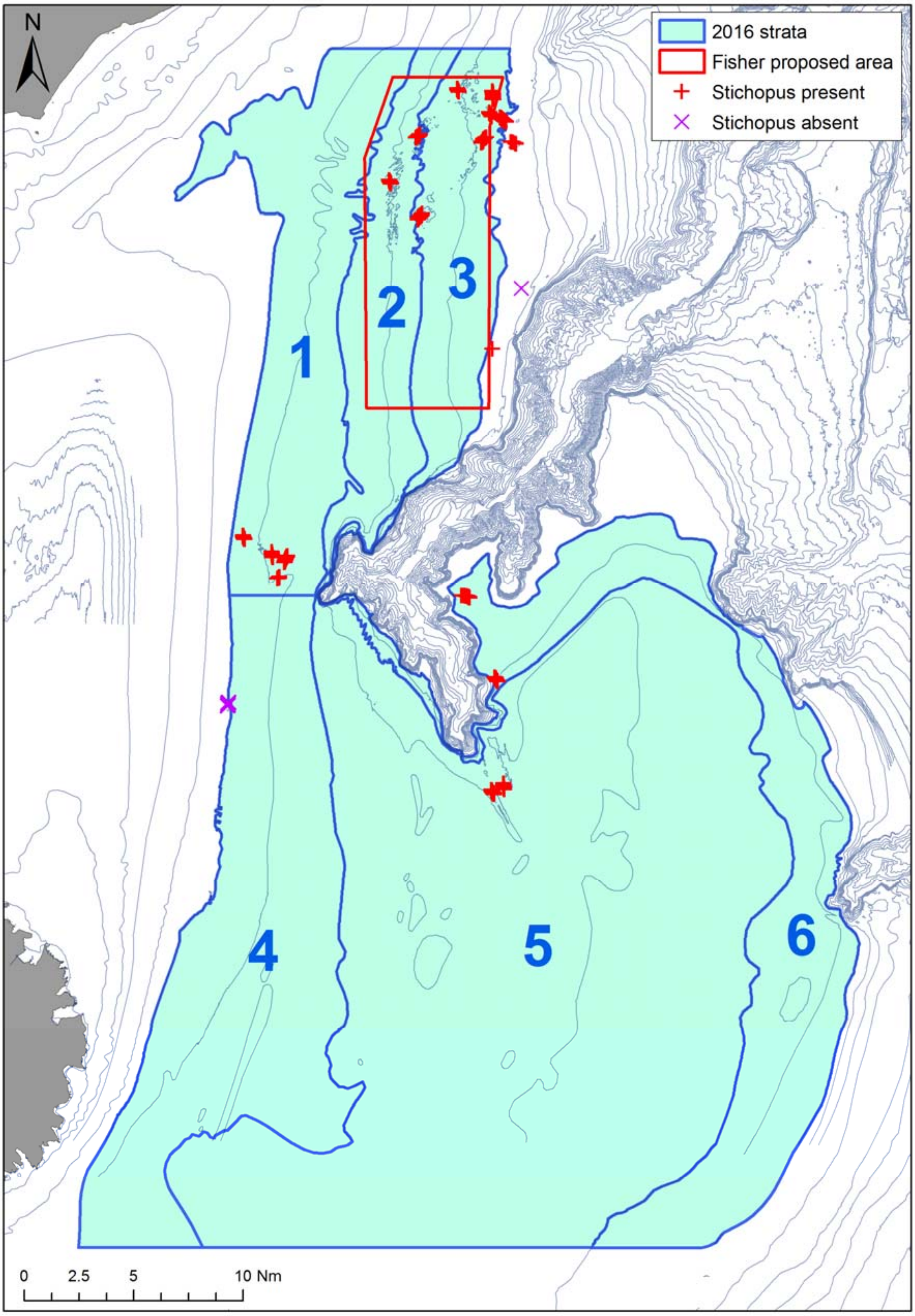

Figure 4: Survey strata in relation to prior information on sea cucumber abundance. The red polygon denotes the area identified by a commercial fisher where sea cucumbers have been caught as bycatch of bottom trawling. Because of this, strata 2 and 3 were the priority strata to be sampled during the survey, with stratum 1 the second priority, and the southern region (strata 4–6) as the third priority. Crosses denote locations sampled during a NIWA biogenic habitat survey (Jones et al. 2016) confirming sea cucumber presence/absence.

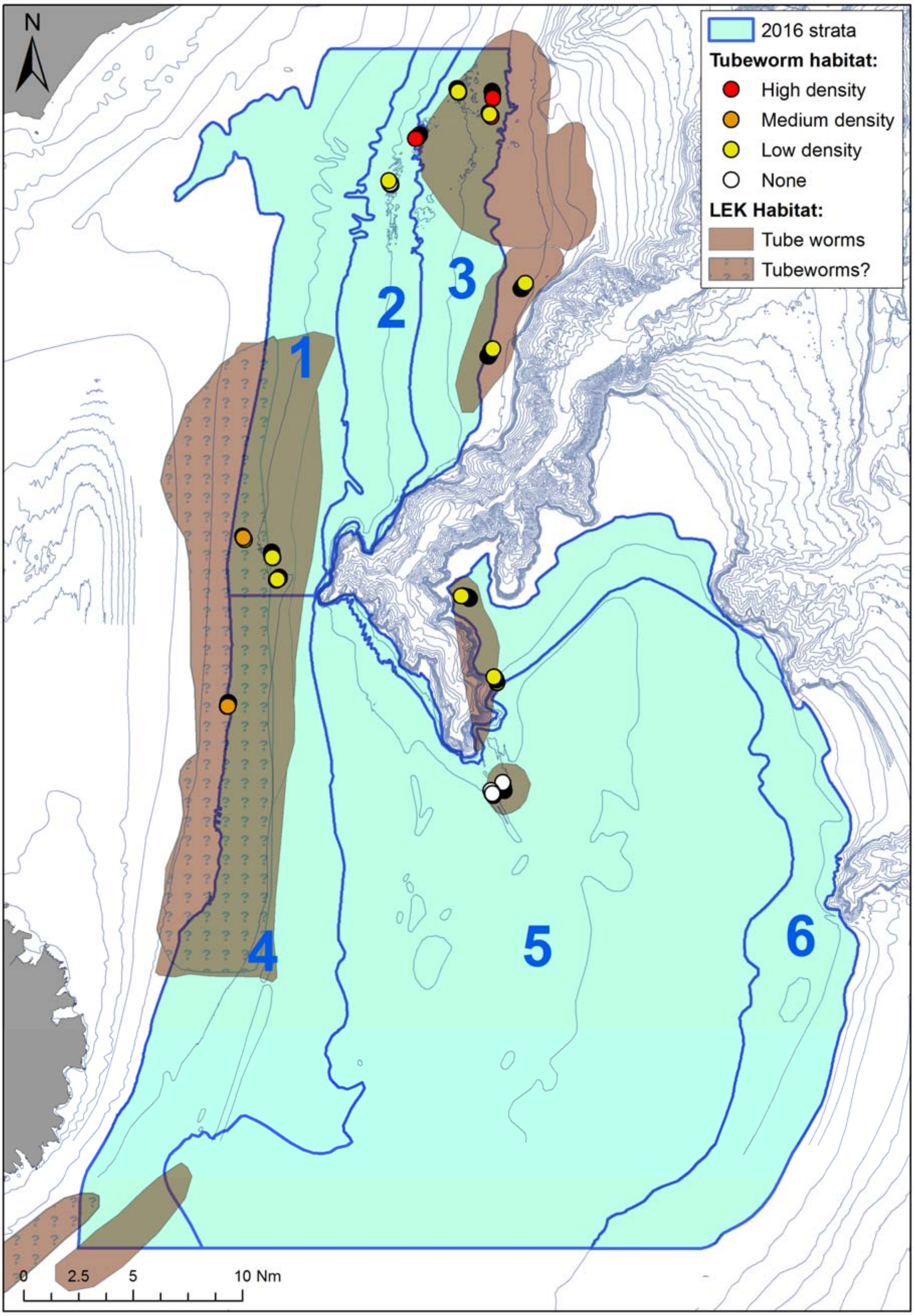

Figure 5: Survey strata in relation to tubeworm habitat identified from a NIWA survey project on biogenic habitats (Jones et al. 2016).

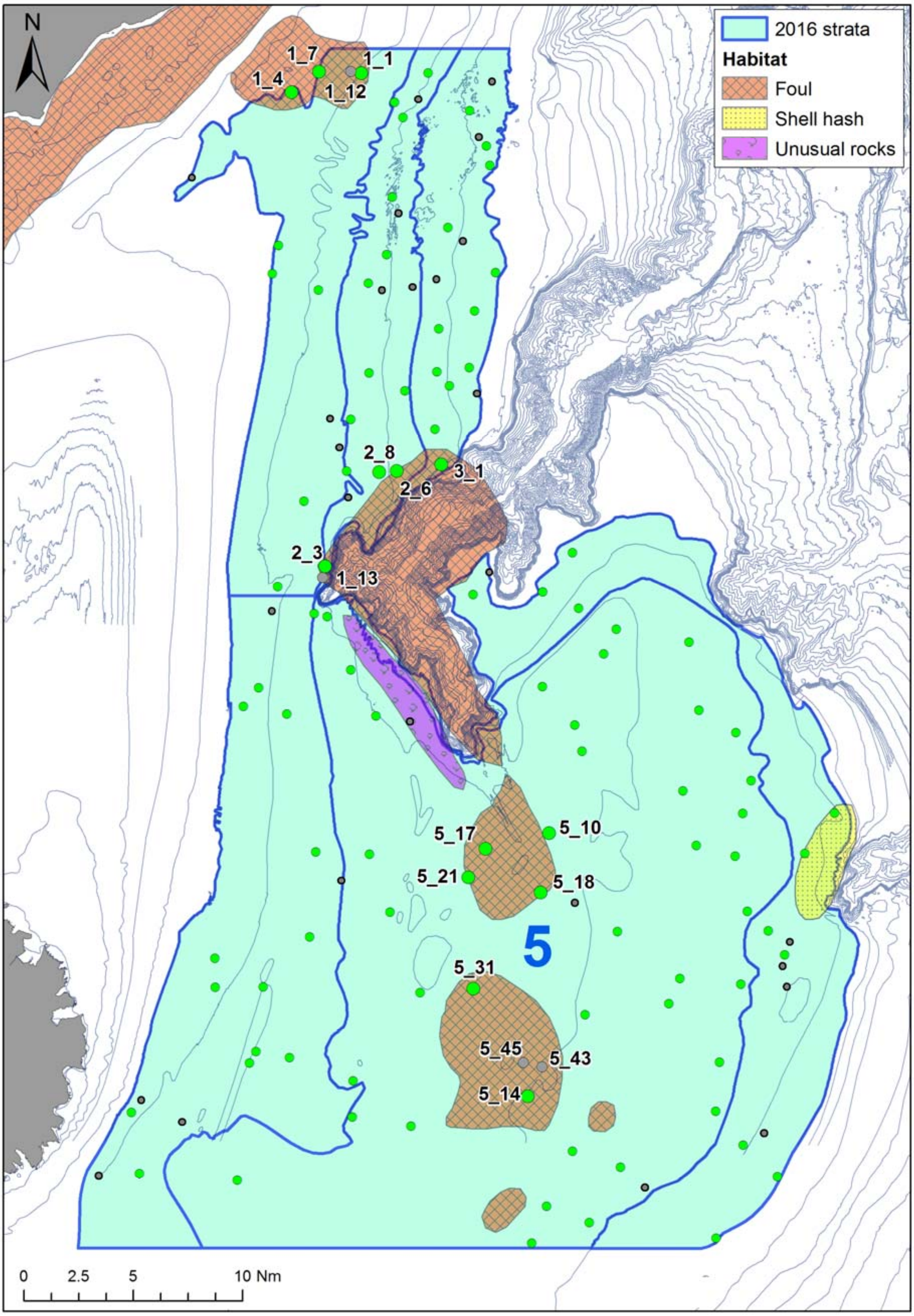

Figure 6: Allocated survey station positions in relation to suspected areas of foul ground, shell hash, and unusual rocky habitats. Station positions shown labelled with their station codes denote those stations that were situated in potentially unsuitable ground for dredge surveying. Additional station positions (grey symbols) were also allocated as alternatives if required.

2.2 Survey design

The survey was conducted in May 2017 using a stratified random sampling allocation design. Sampling was single phase only due to the limited maximum survey duration of five days of sampling at sea.

A total of 100 stations were allocated, assumed to be the number of tows possible within five days of sampling. Stations were allocated proportional to stratum area except in strata 2 and 3 where the allocation was doubled because of the expected higher abundance of sea cucumbers in those strata (based on previous survey and fisher information). Strata 2 and 3 were the priority strata, stratum 1 was the second priority, and strata 4–6 in the southern region were the third priority. The number of stations allocated to each stratum is shown in Table 1. Station positions within strata were randomised using Geographic Information System (GIS) software, constrained to keep stations a minimum distance (1 n.mile) apart. This software was also used to estimate the area of each stratum.

Table 1: Stratum details for the SCC 3 dredge survey, May 2017 and the number of proposed and completed stations. Areas were calculated using ArcGIS® software by ESRI; the total survey area (extent) was 3816 km^2.

Stratum	Region	Depth (m)	Area (km^2)	Proposed stations	Completed stations
1	North	60–80	392.49	9	13
2		80–100	214.83	12	12
3		100–120	221.48	12	13
4	South	60–80	615.38	14	9
5		80–99	1862.54	42	21
6		100–120	509.67	11	8
			3816.39	**100**	**76**

2.3 Dredge sampling

Dredging was undertaken from a chartered fishing vessel (*Pursuit II*) using a 2.4 m wide commercial ring-bag dredge of similar type to that used in scallop surveys in SCA 7 (e.g. see Williams et al. 2017). A standard procedure for dredge sampling was followed. In this procedure, the vessel was positioned at each random station position allocated with non-differential GPS. A single dredge was deployed and towed for a standard tow length of 0.5 n.miles. The actual tow length (distance towed) was also calculated from the logged GPS positions at the start and end of the tow, and a log of the vessel path during the tow was also recorded (using independent data logger technology: Voyage Tracker software, Lennard Electronics, Wellington) which potentially provides a more accurate estimate of the distance towed. The tow started when the winch brakes were set, and ended when hauling with the winch commenced. The vessel skipper was instructed to fish the gear (tow towards the next station, maintain constant target speed of 2.8 knots, and maintain consistent warp to depth ratio) to maximise the total catch at that station while avoiding crossing stratum boundaries, depth contours, foul ground, and obstructions. At the end of the tow, the dredge was retrieved and the dredge contents were emptied onto a sorting tray at the stern of the vessel. Bottom type was categorised after visual inspection of the sediment type present in the dredge contents. All station data (e.g. date, station number, tow start and finish times and positions, depth, dredge performance, bottom type) were recorded on pre-printed NIWA Station Records forms.

2.4 Catch sampling

A standard dredge catch sampling procedure was followed at each station. In this procedure, a photograph of the entire catch was taken before any sorting was done. The total volume of the unsorted catch was visually estimated and recorded to the nearest 0.1 of a standard size fish case (‘fish bin’). For example, the total catch could be 5.5 fish bins.

Sea cucumbers
All live sea cucumbers were sorted from the entire catch and placed into fish bins. The main species expected was *Australostichopus mollis*, but all species of sea cucumber encountered were quantified separately. Species were identified using identification guides, and photographs were taken for later identification purposes when necessary. For each species of sea cucumber, the total count of individuals was recorded, and the volume of sea cucumbers was visually estimated to the nearest 0.1 bin. The aggregate green weight of sea cucumbers was weighed using motion compensated (Marel) scales and the weight recorded to the nearest 0.1 kg (or as accurately as the weighing scales permit).

Each individual sea cucumber was then processed or ‘split’ by inserting scissors into the anus and making a ventral cut longitudinally (about two thirds of the way along the body length) and the individual was cleaned/drained of fluid and guts. Once all sea cucumbers from the catch had been split, the aggregate split-weight of all processed sea cucumbers was determined using motion compensated scales and recorded to the nearest 0.1 kg.

The processed sea cucumbers were placed in a sample bag (or bags, labelled with the station number and sample number i.e. 1 of 2) and stored on ice for the duration of the trip leg and during transit back to port. No subsampling was required. These samples stored on ice were processed to determine individual split-weights (to the nearest 0.1 g) for characterising the population size frequency distribution.

Bycatch
For taxa that were easily counted (e.g. fish, starfish, octopus), individuals were sorted from the catch and placed into bins by taxonomic category. All individuals in each category were counted, and the volume of each category was visually estimated to the nearest 0.1 bin. The remaining unsorted catch was characterised by estimating its total volume (number of bins) and the percentage composition in different taxonomic categories (e.g. sponges, ascidians, bryozoa, echinoderms, crustaceans, bivalves, gastropods, cephalopods, algae, shells or other substrate present). Life status (live or dead) was recorded where appropriate. Photographs were taken of categories for identification purposes where required, remembering to ensure that the station number was visible in each photo. Of particular interest on this survey was the quantity of ‘wireweed’ tubeworms caught, and where possible specifying whether the tubeworms were live or dead (see Figure 5 for areas where tubeworms were expected). All catch data (species counts, volumes and percentage compositions by category) were recorded on pre-printed waterproof forms.

2.5 Biomass estimation

The mean density (in numbers or weight) of SCC at a given station was estimated as the number or weight of animals divided by the swept area. For any given stratum, the mean density and its associated variance was estimated using standard parametric methods, giving each station an equal weighting. The total number or weight of SCC in the stratum was estimated by multiplying the mean density by the estimated area of the stratum. The overall mean density of SCC in the survey area was estimated as the weighted average mean density, and the variance for this overall mean was derived using the formula for strata of unequal sizes given by Snedecor & Cochran (1989):

For the overall mean, $$\bar{x}_{(y)} = \sum W_i . \bar{x}_i$$

and its variance, $$s^2{}_{(y)} = \sum W_i{}^2 . S_i{}^2 . (1 - \phi_i) / n_i$$

where $s^2_{(y)}$ is the variance of the overall mean density, $\bar{x}_{(y)}$, of SCC in the surveyed area, W_i is the relative size of stratum i, and S_i^2 and n_i are the sample variance and the number of samples respectively from that stratum. The finite correction term, $(1-\phi_i)$, was set to unity because all sampling fractions were less than 0.01.

3. RESULTS

3.1 Survey details

The SCC 3 dredge survey was conducted from 9th to 16th May 2017. A total of 76 dredge sampling stations were completed (Table 1, Figure 7). The target number of stations was met or exceeded in the priority (northern strata), but time constraints meant that not all of the planned stations were completed in the southern strata, particularly stratum 5.

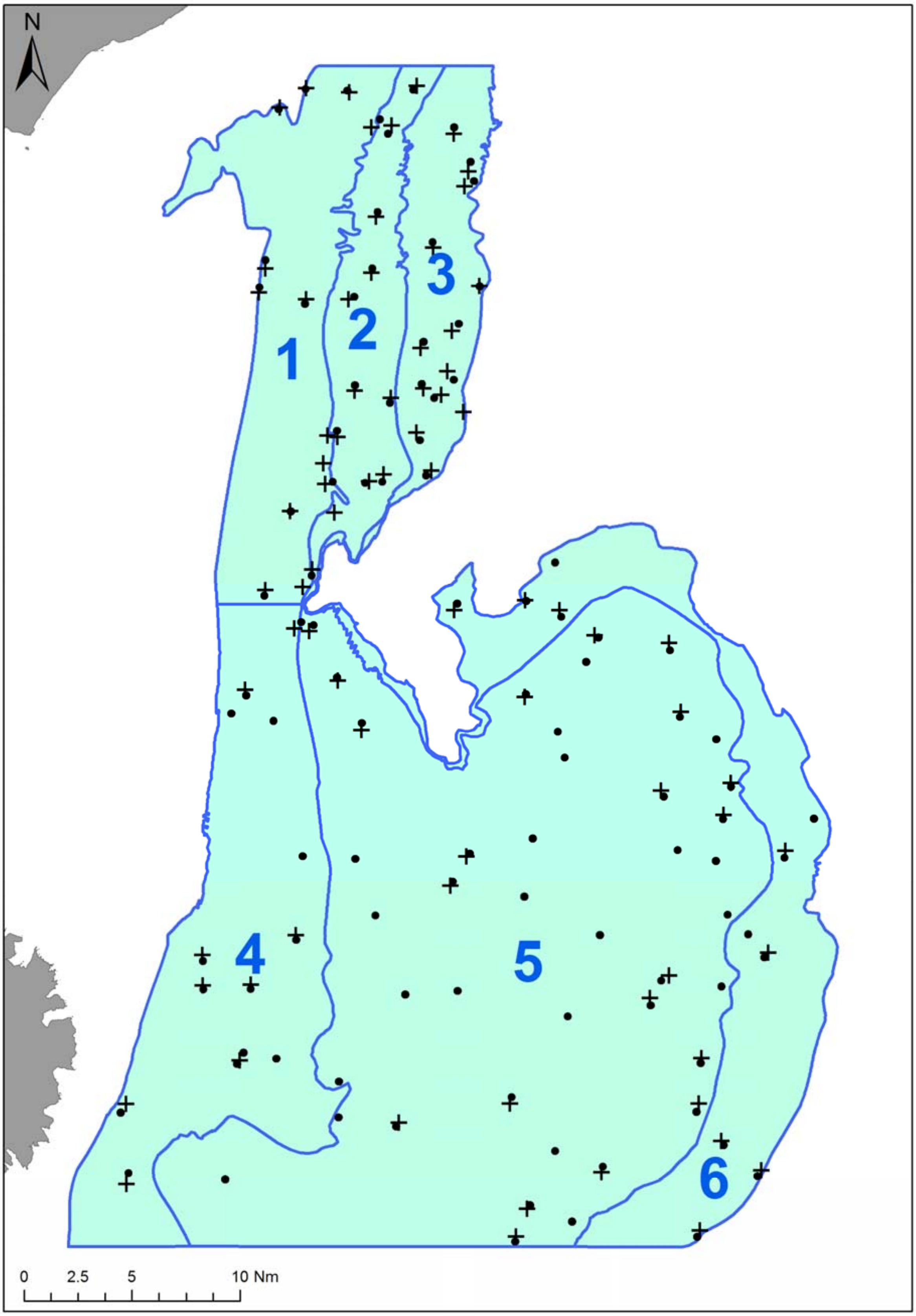

Figure 7: Planned (●) and completed (+) dredge stations within each stratum.

3.2 Distribution and biomass

Sea cucumber (*Australostichopus mollis*) numbers per standard 0.5 n.mile tow for the dredge survey are shown in Figure 8. Catch rates were highest in strata 1 and 2, intermediate in strata 5 and 6, and lowest in strata 3 and 4. While catch rates within stratum 5 were about half that recorded within strata 1 and 2, the large area of stratum 5 meant that this area contributed about half of the total estimated abundance of 23.8 million individuals (16% CV) (Table 2).

Aggregate greenweight was recorded at sea for each station, and was used to estimate the greenweight survey biomass estimate (Table 2). The greatest greenweight per standard tow was recorded in stratum 2, with intermediate levels in strata 1, 5 and 6, and lower levels in strata 3 and 4. The overall survey greenweight biomass estimate was 3207 tonnes (13% CV).

Table 2: Population estimates of abundance (numbers) and biomass (greenweight) of SCC (*Australostichopus mollis*) by survey strata, assuming 100% dredge efficiency.

	Abundance				Greenweight			
Stratum	Mean	SD	Millions	CV	Mean	SD	Tonnes	CV
1	26.08	52.41	4.61	0.56	2.59	4.94	456.76	0.53
2	29.75	31.79	2.88	0.31	3.59	4.07	346.66	0.33
3	7.62	16.38	0.76	0.6	0.93	1.96	92.35	0.59
4	3.11	4.78	0.86	0.51	0.33	0.5	90.91	0.51
5	14.67	10.77	12.29	0.16	2.24	1.46	1879.82	0.14
6	10.5	20.42	2.41	0.69	1.49	2.43	340.56	0.58
Total	13.86		23.8	0.16	1.87		3207.05	0.13

Individual split-weights were weighed and recorded ashore, and summed by station to provide an aggregate split-weight by station. These data were used to estimate the split-weight survey biomass estimate (Table 3). The distribution of split-weight biomass was very similar to that of greenweight biomass, with over half (58%) of the estimated 1329 t (14% CV) held in stratum 5.

Table 3: Population estimates of biomass (split-weight and split-weight greater than or equal to 63 g; tonnes) of SCC (*Australostichopus mollis*) by survey strata, assuming 100% dredge efficiency.

	Split-weight				Split-weight (≥63 g)			
Stratum	Mean	SD	Tonnes	CV	Mean	SD	Tonnes	CV
1	1.09	2.14	192.83	0.54	0.1	0.16	16.79	0.47
2	1.47	1.66	142.32	0.33	0.41	0.56	39.65	0.39
3	0.38	0.76	37.73	0.55	0.07	0.15	7.01	0.59
4	0.14	0.2	38.08	0.49	0	0	0	0
5	0.92	0.63	769.17	0.15	0.54	0.5	455.14	0.2
6	0.65	1.09	149.35	0.59	0.44	0.62	100.91	0.5
Total	0.77		1329.49	0.14	0.361		619.51	17

Other unidentified holothurians were also caught, but in very low numbers.

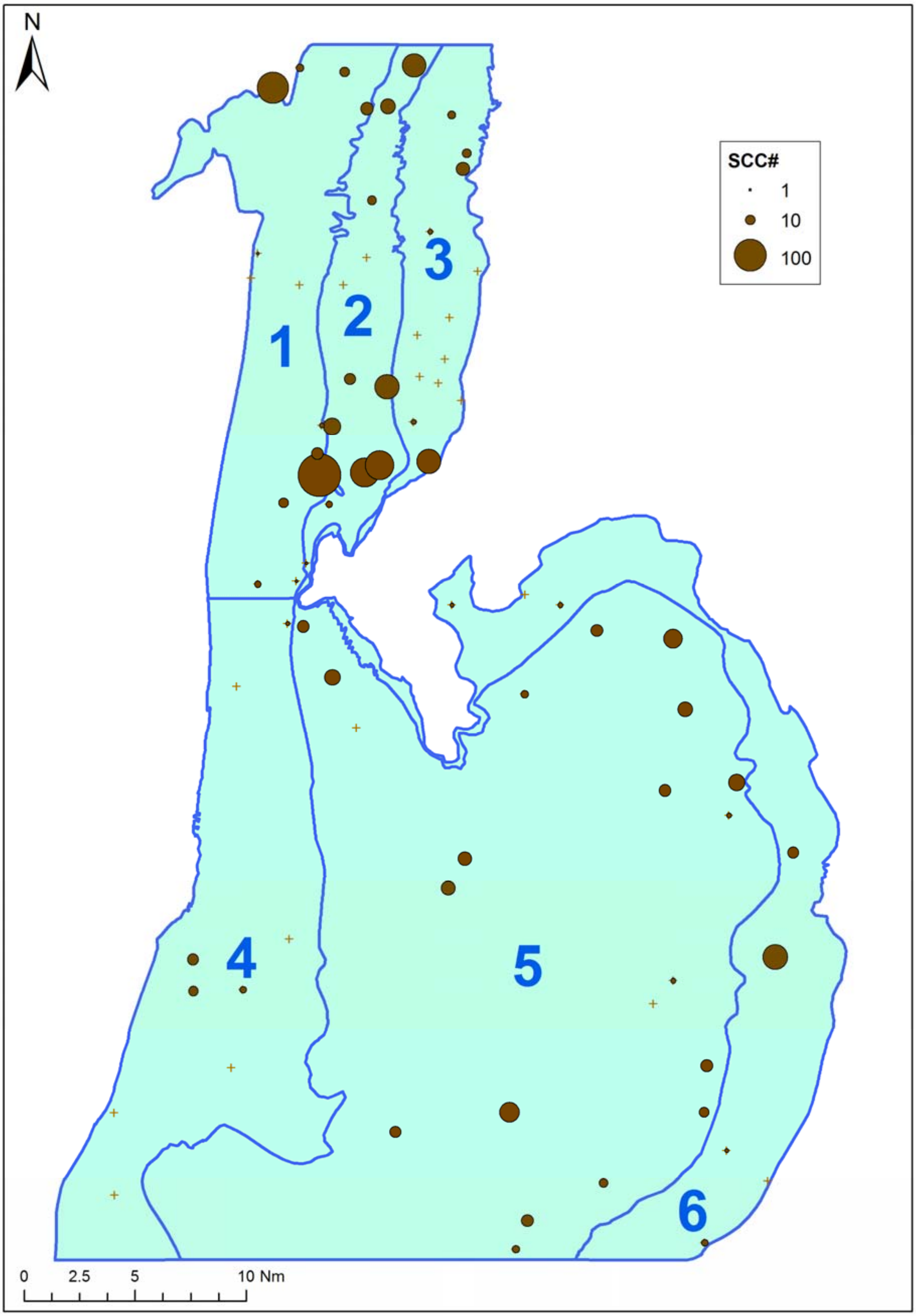

Figure 8: Numbers of sea cucumbers (SCC - *Australostichopus mollis*) per standard 0.5 n.mile tow from the dredge survey in SCC 3 in May 2017. Circle area is proportional to number.

Previous SCC dive survey work conducted in association with a commercial SCC fisher (Williams et al. 2016) estimated the size at which 50% of SCC would be retained (regarded as marketable size) as 63 g split-weight. Excluding all split-weight individuals smaller than 63 g from the SCC 3 analysis results in a split-weight marketable biomass of 620 t (17% CV), just under half the total split-weight biomass. While stratum 5 holds 58% of the total split-weight biomass (Table 2), it holds 73% of the split-weight biomass greater than or equal to 63 g, implying that larger individuals were found in this stratum.

In addition to the parametric approach to biomass estimation (and associated uncertainty) presented above, for the split-weight biomass estimate (total, and individuals ≥ 63g), a non-parametric resampling approach was also applied, where stations were resampled with replacement within strata. For each analysis, the distribution of biomass estimates is presented for 1000 iterations of the resampling process.

For the analysis of all SCC catches (Figure 9), the median biomass estimate was 1326 tonnes (mean 1330 tonnes), with 95% confidence limits from 1005–1700 tonnes. For the analysis of SCC catches larger than the nominal marketable size of 63 g split-weight (Figure 10), the median biomass estimate was 622 tonnes (mean 625 tonnes), with 95% confidence limits from 446–837 tonnes.

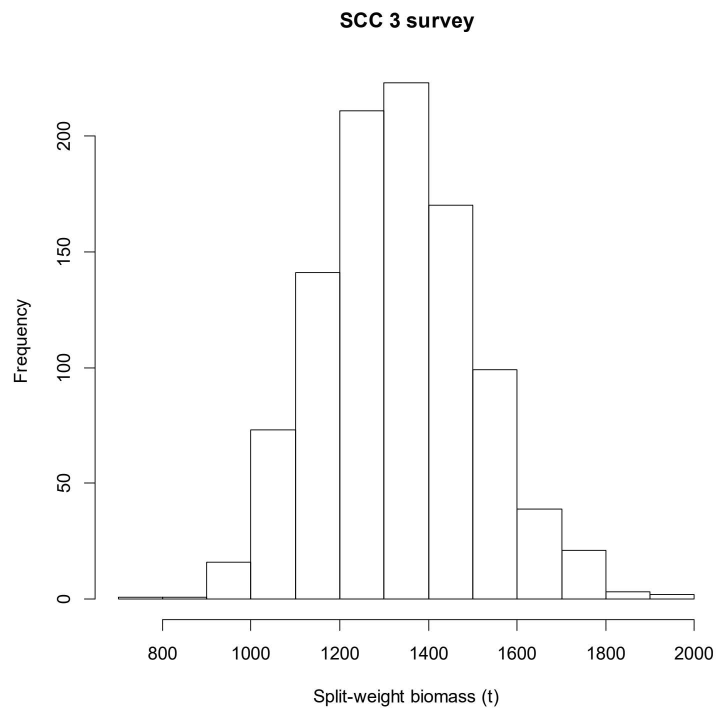

Figure 9: Distribution of biomass estimates from a non-parametric resampling approach, stations were resampled within strata.

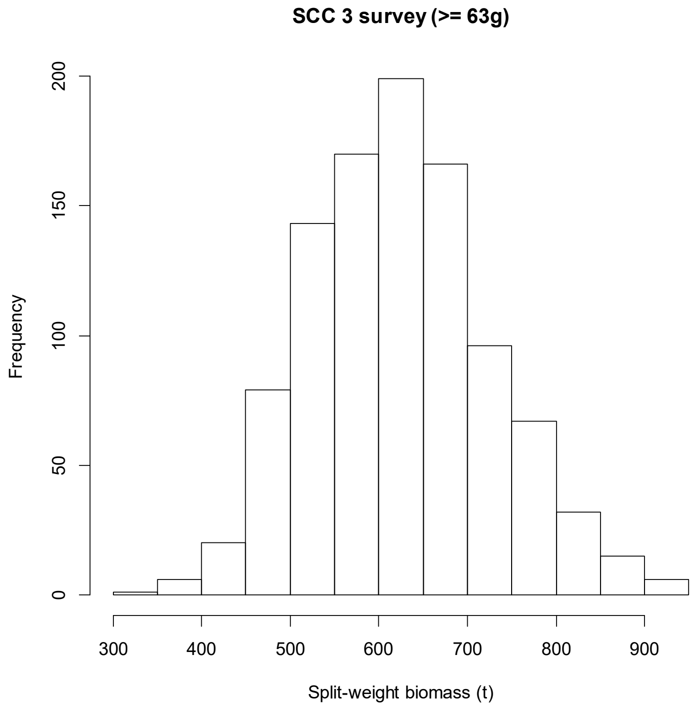

Figure 10: Distribution of biomass estimates for SCC weighing 63 g or more from a non-parametric resampling approach, where stations were resampled within strata.

3.3 Greenweight to split weight conversion

Aggregate greenweight (weight of total SCC catch) and split-weight (sum of individual split-weights) catch estimates were available for each survey station, and the relationship between them is shown in Figure 11. This equates to a split-weight to greenweight conversion factor of 2.41, or a greenweight to split-weight conversion factor of 0.415.

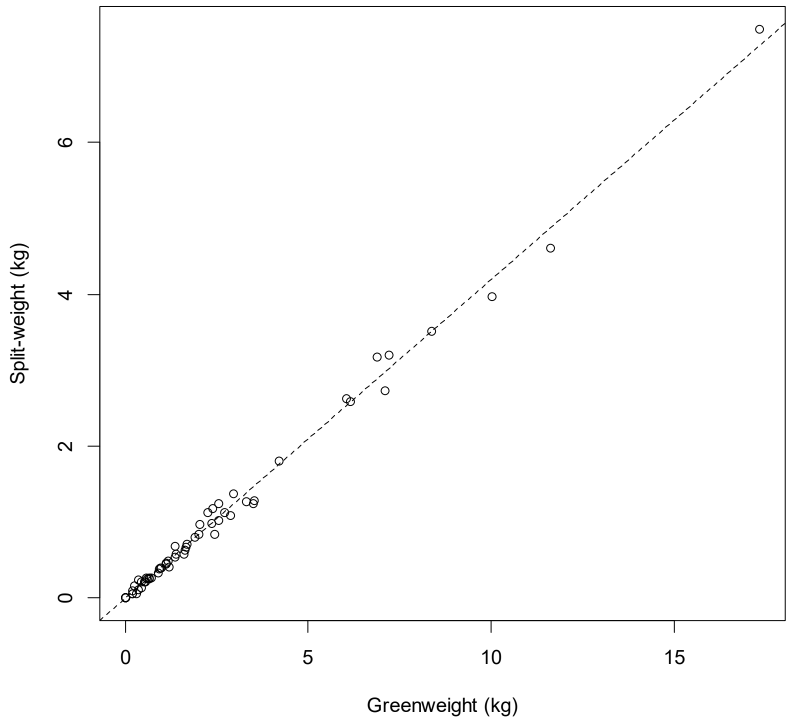

Figure 11: Relationship between aggregate greenweight and aggregate split-weight SCC catch for each of the survey stations, with the least squares regression fit shown (slope = 0.420102, intercept = -0.010256, r^2 = 0.99).

3.4 Size frequency

Sea cucumbers sampled on the SCC 3 survey ranged in size (weight) from 10 g to 136 g split-weight. The primary modal size was just under 50 g (Figure 12), and the proportion of larger individuals varied considerably among strata. The overall split-weight size composition of the SCC population within the survey area is shown in Figure 13.

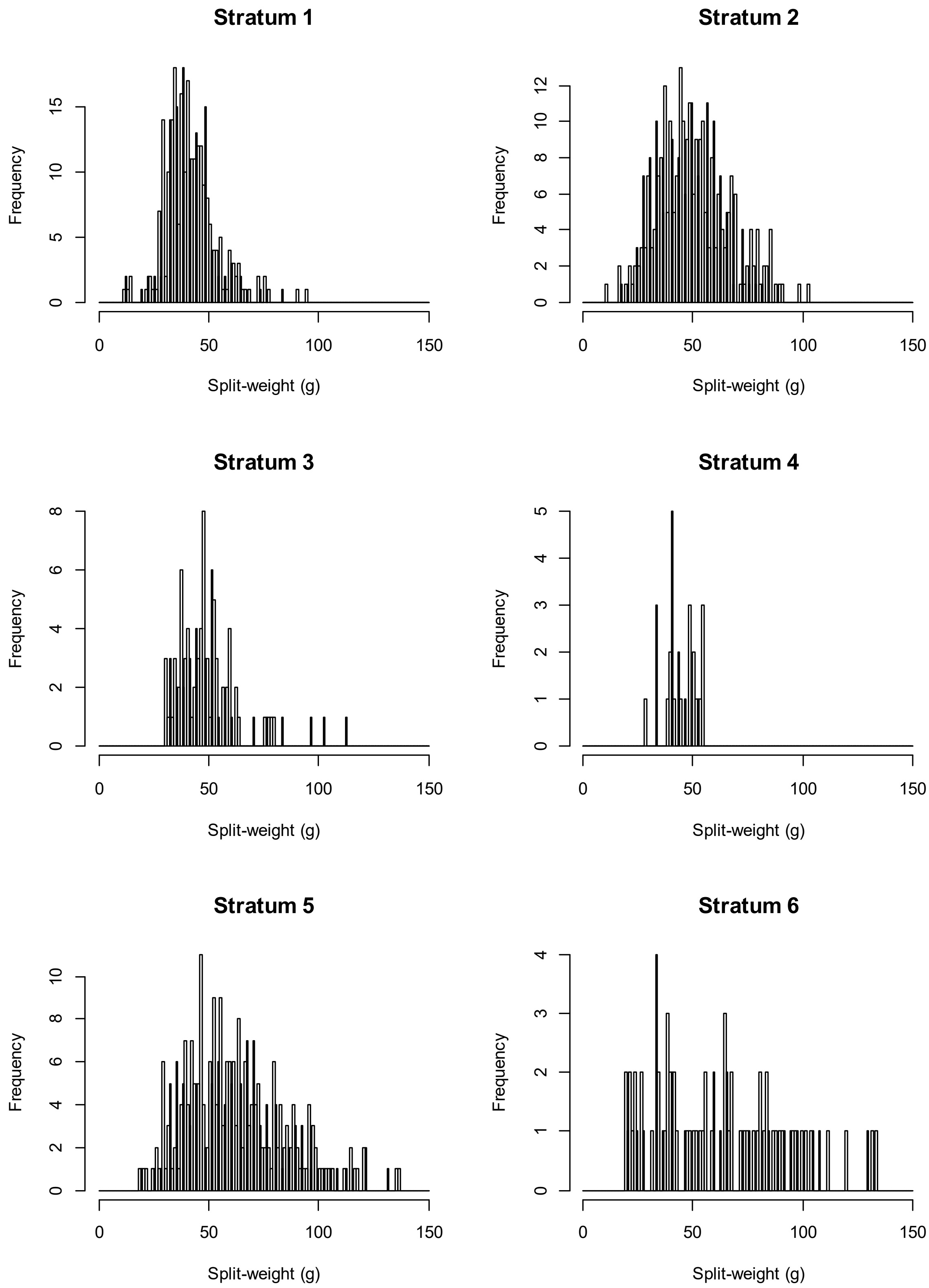

Figure 12: Frequency distribution of sea cucumber split-weight (g) by survey stratum.

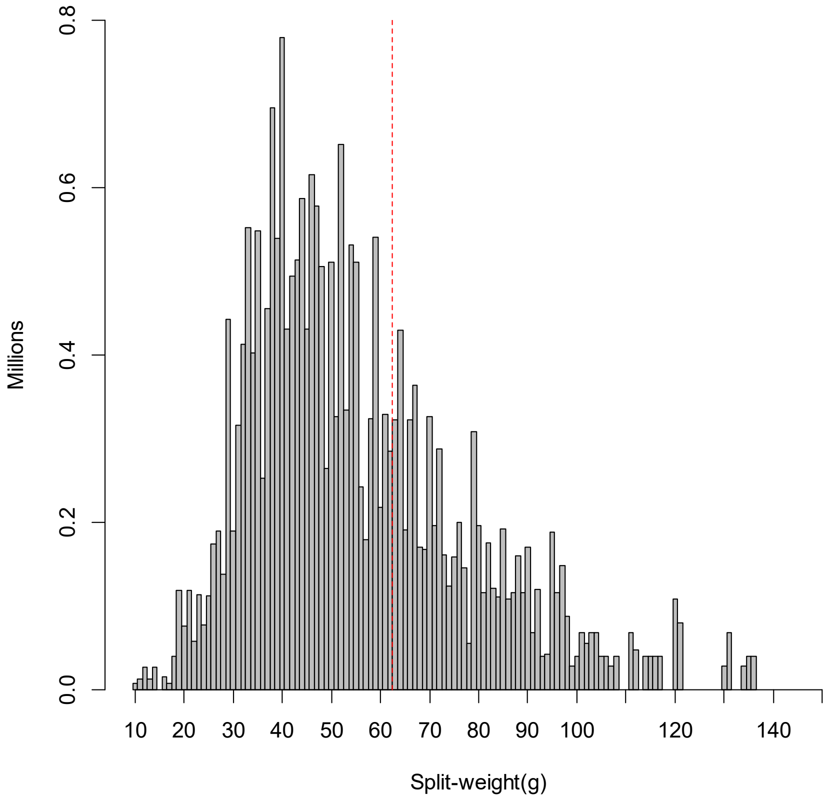

Figure 13: SCC numbers at split-weight, raised to the survey area. Red dashed line indicates a split-weight of 63 g, previously identified as the L_{50} of commercial SCC selection.

3.5 Bycatch

The complete catch from the survey tows was weighed and recorded in broad categories. The full dataset has been saved within the MPI *scallop* database, for voyage (trip_code) PUR1701. The total catch from the 76 survey tows was 916 kg.

Across the whole survey, the main component of the catch was substrate, comprised of rocks and shells (285 kg, 31%). The main invertebrate faunal component of the bycatch was hydroids (220 kg, 24%), although this was made up of a small number of large catches (Figure 14). Sea cucumbers were the second most dominant invertebrate component (150 kg, 16%), followed by asteroids (starfish) (90 kg, 10%), bivalves (37 kg, 4%) and decapods (33 kg, 3.5%).

A range of fish species were also caught (63 kg, 7%), predominantly rough skate (*Dipturus nasutus*), witch (*Arnoglossus scapha*) and carpet shark (*Cephaloscyllium isabellum*).

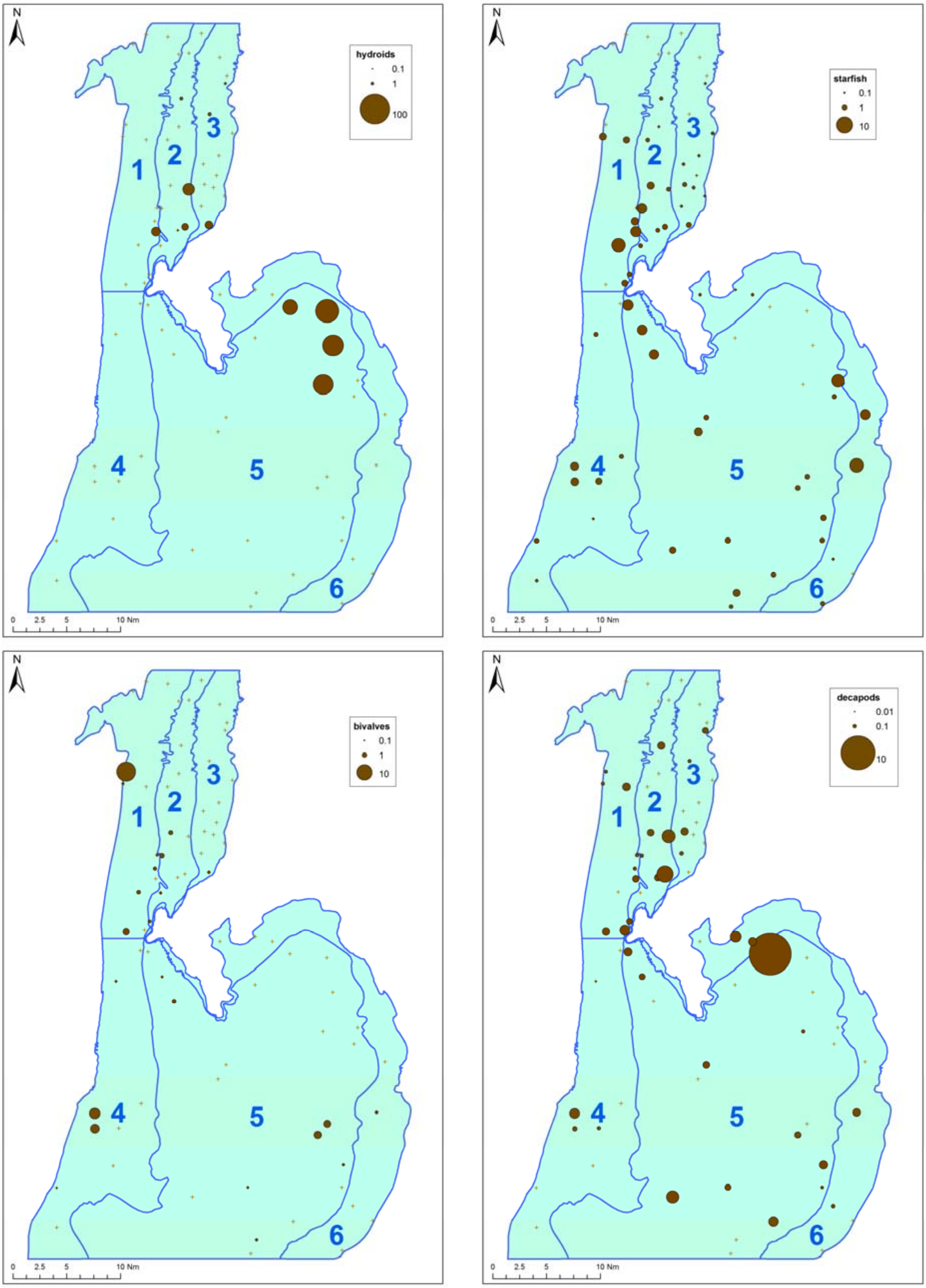

Figure 14: Bycatch (kg) of main faunal categories per standard 0.5 n.mile tow from the dredge survey in SCC 3 in May 2017. Circle area is proportional to weight.

4. DISCUSSION

Through examination of trawl survey data, MPI observer records, data collected within MBIE-funded Coastal Conservation Management (CO1X0907) and MPI-funded Biogenic Habitats (ZBD200801) projects (Jones et al. 2016), and discussions with commercial sea cucumber fishers, we identified an overall survey area off the northern coast of Canterbury (SCC 3), and priority strata where SCC were expected to be more abundant. Reported landings (from trawl bycatch) within SCC 3 have consistently exceeded the TACC of 2 tonnes in recent years.

Our dredge survey was completed successfully, and provided an estimate of 23.8 million SCC (16% CV), with a greenweight of 3207 tonnes (13% CV) and split-weight of 1329 tonnes (14% CV). The collection of individual split weight data from the whole SCC catch allowed estimation of greenweight to split-weight (aggregated to the station catch level) conversion ratios (see Section 3.3), and examination of the size composition of the catches. Previous SCC dive survey work conducted in association with a commercial SCC fisher (Williams et al. 2016) has estimated the size at which 50% of SCC would be retained (regarded as marketable size) as 63 g split-weight. Excluding SCC smaller than 63 g split-weight provided a survey estimate of 619 tonnes (17% CV) of marketable SCC biomass. Biomass estimates using a non-parametric resampling approach (resampling SCC within stations, and stations within strata) provided similar estimates to the parametric approach. These estimates assume 100% dredge efficiency, and therefore may be conservative.

The Total Allowable Commercial Catch (TACC) for SCC 3 is currently 2 t, although reported landings exceeded 8 t in 2012–13, and have averaged 5.6 t since 2011–12. Making the conservative assumptions that the dredge is 100% efficient, that all of the reported landings originated from the survey area, and that all landings were of commercial size individuals, then landings (since 2011–12) would represent up to 1.2% (mean 0.9%) of the point estimate of commercial SCC biomass (622 t, median from resampling approach), or up to 1.8 % (mean 1.2%) of the lower 95% CI of commercial SCC biomass (446 t). The SCC 3 management area is considerably larger than the area covered by the survey, and it was not possible to estimate the biomass at the stock-wide level within this project.

On the basis of the biomass estimates provided by the present study, sustainable harvest (yield) estimates could be generated using methods appropriate for sea cucumbers or similar sedentary species. Yield estimation would also require estimates of biological parameters relating to natural mortality, growth and maturity, depending on the approach considered most appropriate to estimate sustainable harvest. Currently there is little information in the New Zealand literature to guide appropriate estimates of these parameters for *A. mollis* (see review by Zamora & Jeffs 2013). Natural mortality in the wild is a key unknown parameter, but if an appropriate value cannot be found in the literature, sensitivity to a likely range of estimates could be examined. Aquaculture studies may provide some guidance, and it has been suggested that sea cucumbers live for about five years (Stenton-Dozey, NIWA, pers. comm.). An emphasis on spatial considerations in the method of assessment will be necessary given the likely strong spatial structure inherent in *A. mollis* populations, and the concentration of the fisheries on dense aggregations which may form the most important component of the spawning biomass. Drawing on assessment frameworks used for other species of sea cucumber overseas (e.g. Duprey et al. 2010) will be beneficial. Research in Canada has suggested a conservative annual harvest rate of 6.7% of current biomass, if unproductive, low density areas are avoided (Hand et al. 2009).

5. ACKNOWLEDGMENTS

This work was funded by the Ministry for Primary Industries (MPI) through project DEV201401. The work would not have been possible without the help and support of the skipper (Dennis Roach) and crew (Jesse Roach and Mike Davies) of the FV *Pursuit II*. Thanks to MPI fisheries science and management staff for valuable input, particularly Rich Ford, Erin Breen, and Mike Cowling. Discussions with, and advice and help received from Reyn Naylor, Brent Wood, and Ian Doonan (NIWA) are greatly appreciated. We are grateful to members of the Shellfish Fisheries Assessment Working Group for their appraisal of the survey methodology and review of the results. This report was reviewed at NIWA by Reyn Naylor.

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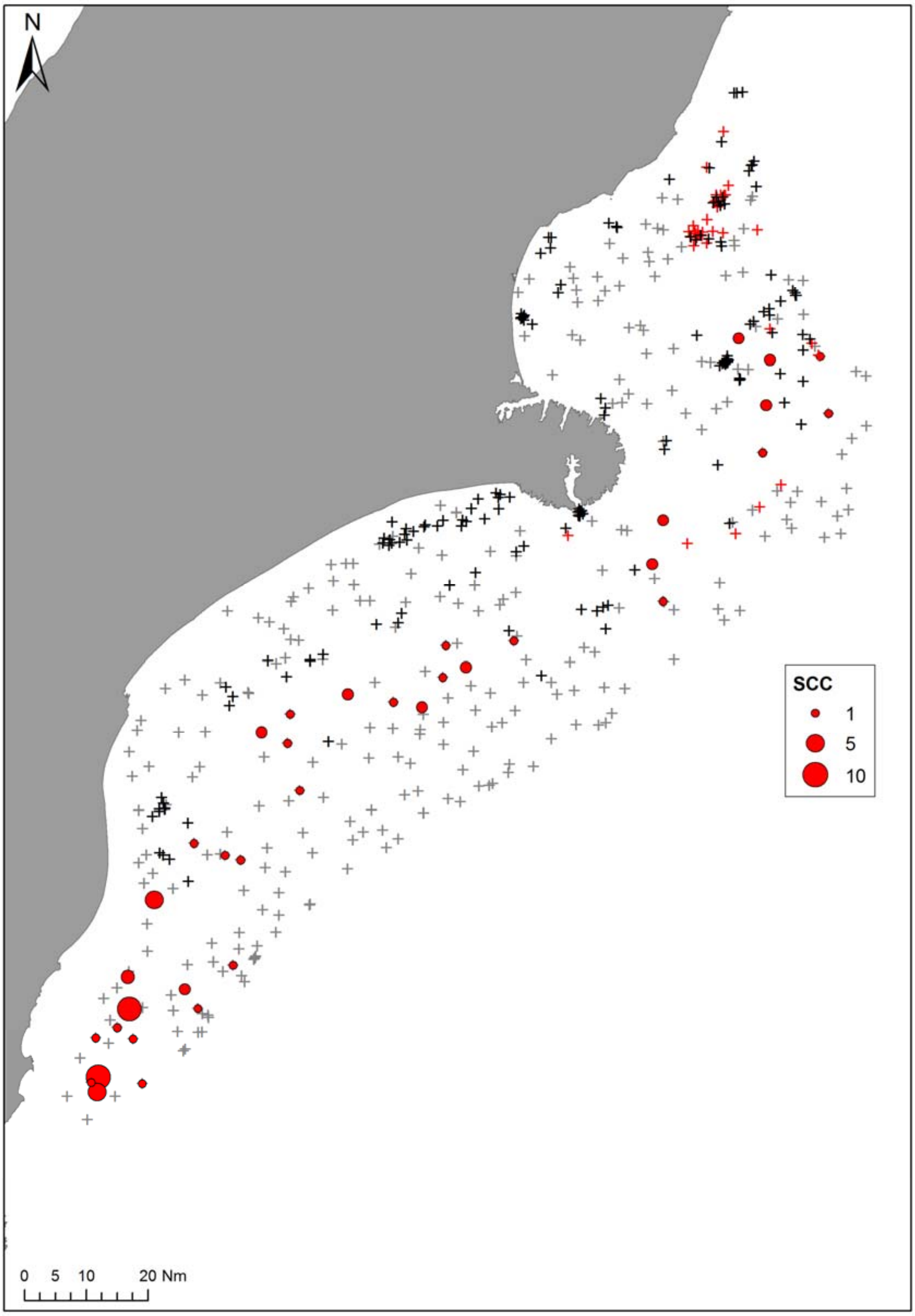
Appendix



Trawl survey and MPI inshore observer records for SCC 3 area. The red circles reflect trawl survey catch (kg per tow), red crosses reflect SCC catch recorded by MPI observers on recent inshore trips, and grey and black crosses reflect trawl survey and observer records with no SCC catch.