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The Status of Iceland Scallop (*Chlamys islandica*) in the Strait of Belle Isle (SFA 14A, Div. 4R) in 2018

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

The directed fishery for Iceland scallop (*Chlamys islandica*) in the Strait of Belle Isle (Northwest Atlantic Fisheries Organization [NAFO] Div. 4R) has been prosecuted annually since 1969 with the exception of four years (1975–79). Populations in the Strait of Belle Isle are found on three beds at depths from 30–120 m. They are usually on hard bottom with variable substrate composition consisting largely of sand, gravel, shell fragments, and stones. Landings have averaged approximately 250 t since 2009, with lower than average landings of 115 t and 127 t in 2017 and 2018 respectively. The total allowable catch of 1000 t has not been taken since 2000. Catch per unit effort over the last decade has remained stable. The number of active licenses has declined in recent years to its lowest level. Since 2006 more than 90% of the landings has been taken from Bed 3 (southern bed). Fisheries and Oceans Canada (DFO) resource assessment surveys in September 2011 and 2018 resulted in minimum dredgeable biomass (MDB) estimates of 4,123 (t, round) and 3,432 (t, round) respectively. For the duration of the survey time series (since 1995) the MDB estimates have varied without trend. The natural mortality estimate was 0.26 in 2018 which was the highest in the survey time series.

INTRODUCTION

SPECIES BIOLOGY

The Iceland scallop (*Chlamys islandica*) is widely distributed within the subarctic, but is also found in fishable aggregations as far south as the coast of Massachusetts. Populations in the Strait of Belle Isle area are found on three beds at depths from 40–100 m. They are predominantly found on hard substrates, consisting largely of sand, gravel, shell fragments, and stones (DFO 2001). The Iceland scallop is a filter-feeder, consuming plankton and detritus, and is associated with areas of strong currents. To reside in such areas, the scallop is attached to the substrate by a byssal thread. Unlike other scallops, the byssus is maintained to the adult stage.

Iceland scallop are dioecious (having separate sexes), become sexually mature at 3–6 years of age, and fully recruit to the commercial fishery at approximately 60 mm shell height (age approximately 7–8 years). Spawning in Newfoundland waters begins in April to May and is thought to be initiated by short-term variation in temperature. Eggs are externally fertilized and larvae are planktonic for as long as 10 weeks before settling to the bottom, possibly at considerable distances from the spawning adults. Iceland scallop frequently live more than 25 years, but seldom exceed 100 mm in shell height (DFO 2009).

THE FISHERY

The fishery in the Strait of Belle Isle is the longest existing scallop fishery in Newfoundland and Labrador, (starting in 1969) and has been prosecuted annually with the exception of four years (1975–79). The number of active licenses has ranged from a high of 107 in 1985 to the current low of eight licenses on average in the last three years (Table 1). The fishery has been cyclical in nature, often driven by market considerations.

The fishery has been regulated by a total allowable catch (TAC) since 1996. Other management measures include weekly catch limits and spatial regulation of removals. The majority of vessels in this fishery are less than 45’ length overall (LOA). They make daily excursions and land fresh product with nearly all scallops shucked at sea.

The fishery in the Strait of Belle Isle for Iceland scallop takes place in three main scallop beds, which are considered a single stock for assessment purposes. Bed 1 is the most northerly, Bed 3 is the most southerly and Bed 2 is between Beds 1 and 3 (Figure 1). Aggregations in the Bed 3 were heavily fished throughout the 1990s, with greater than 90% of the total landings sometimes coming from this bed. In an attempt to redistribute effort to the northern beds, it was decided in 2000 to partition the TAC equally north and south of the 51°25’ latitudinal line (Figure 1). As well, in 2000, in consultation with stakeholders, a refugium (a corridor 5 miles wide across the Strait of Belle Isle) was established in hopes of promoting survival of newly settled scallop in the absence of fishing. In 2009, after a review and assessment of the stock it was determined that there were limited benefits to the stock and the refugium was eliminated. In 2014, upon request and after agreement between fish harvesters and the proponent, DFO closed an area to all scallop dragging in the Strait of Belle Isle Scallop Fishing Area (SFA) 14 to protect a submarine transmission cable and berm (8.07 nM2) located along the 51 latitudinal line near the northern part of Bed 3 and southern tip of Bed 2 (Figure 2) (DFO 2016).

METHODOLOGY

THE FISHERY

The fishery landings data are based on dockside monitoring reports, harvesters logbooks and purchase slips from buyers. The harvesters report the daily catch for each week of the fishery.

RESEARCH VESSEL SURVEYS

Survey Design

Fisheries and Oceans resource assessment surveys were conducted in 1995–97, and 2000 onboard the *CCGS Wilfred Templeman* and in 1999, 2007, 2011 and 2018 onboard the *CCGS Alfred Needler*. Between 1995–2000, bottom mapping techniques were used to delineate scallop habitat, resulting in the identification of three strata or beds (referred to as beds throughout this document) in the survey area. The original survey strata used from 1995–99 were redesigned to match the stratification scheme used in consecutive surveys for comparison (DFO 2009).

All of these surveys were completed using a stratified random sampling scheme. Stratification was based on area and depth. Sets were optimally allocated in proportion to stratum-specific areas and variance of the catch rates. The sets allocated for the 2018 resource assessment survey were based on the variance in catch from the 2011 survey.

Sets were optimally allocated to minimize the variance of the mean for a fixed sample size in a stratified random sampling scheme according to Cochran (1977):

$$n_h = \frac{n\, A_h\, S_h}{\sum (A_i\, S_i)}$$

where n_h=number of sets in stratum ‘h’, n=total number of sets available, A_h=area of stratum ‘h’, and S_h=Variance in stratum ‘h’, A_i = area of each stratum, and S_i = variance in each stratum.

Fishing Methods

An 8-foot scallop dredge equipped with 3” rings and interconnected with 3-top and 4-bottom link configuration was used in the resource assessment surveys. Standard tow length was 0.5 nm and the towing speed was approximately 3 knots with a warp (wire length) to depth ratio of 3 warp length (meters) to 1 water depth (meters). All tows passed through the allocated position with tow direction being random except if the position was too close to the stratum (bed) border or an obstruction, then the direction was so that the tow could be completed within the stratum and/or to avoid the obstruction.

Sampling

Upon completion of each tow, the total catch was sorted by species, numerated, and weighed. Live scallops were bushelled into baskets and weighed whole. Depending on the volume of the catch and anticipated steam time to the next fishing station, either the whole catch or a randomly selected weighed subsample was set aside for individual shell-height measurements to the nearest mm. Individual shell height and meat weight information was also collected from a subset of scallop sampled in each stratum. Cluckers (empty persistent paired valves still attached at the hinge line) were separately sorted, weighed, counted, and measured. Clucker weights and the weight of residual debris (e.g., sand, broken shell fragments, and pebbles) were subtracted from sampled and total catch weights.

In addition, predatory sea stars were sorted by species and sampled for individual weight and length. The length of each sea star was measured from the mouth to the end of an arm to the nearest mm. Commercial finfish such as Atlantic Cod (*Gadus morhua*) and American Plaice (*Hippoglossoides platessoides*) were also sampled for length, sex, and stomach contents.

Each station was not occupied until the sampling from the previous set was completed. This guards against water loss in the scallops which can affect the weights recorded, subsequently affecting biomass estimates.

BIOMASS

Abundance and MDB indices for Iceland scallop and sea star species were calculated for each survey using Stratified Analysis Programs (STRAP) (Smith and Somerton 1981) from swept area estimates within each of the three beds. All surveys were standardized to 0.5 nm tow to account for the distance of each tow.

The MDB and abundance indices based on the resource assessment surveys over the survey time series (i.e., 1995–97, 1999, 2000, 2007, 2011, and 2018) were displayed in bar graphs for all beds combined within the Strait of Belle Isle and the MDB was also displayed for each of the three beds in the area to show the comparative trends.

Biomass estimates were inflated by inclusion of epibionts (organisms that live on the surface of other living organisms) in the catch weight. However, this bias is not thought to affect trends in biomass because epibionts abundance would be considered consistent from year to year.

NATURAL MORTALITY

Natural mortality of Iceland scallop was computed directly from percent occurrence of cluckers (Dickie 1955) according to the equation:

$$M = 1 - e\left(\frac{C}{t}\right)\left(\frac{1}{L}\right) * 365$$

where M = annual mortality rate, C = number of cluckers in a sample adjusted to account for tow-induced disarticulation (number of cluckers*1.211) (Naidu 1988), L = number of live scallops in a sample, and t = average time in days (210.8) required for natural clucker disarticulation (Mercer 1974).

MEAT YIELDS

During the resource assessment surveys, Iceland scallops were collected to determine biological meat yields (%), average meat weight (g), and meat counts (number of meats/500 g) in each of the 3 beds.

Meat count is given by the formula:

$$x = \frac{500\ (g)}{meat\ weight\ (g)}\ X\ sample\ (n)$$

Biological meat yield is given by the formula:

$$x = \frac{meat\ weight\ (g)}{round\ weight\ (g)}\ X\ 100$$

SIZE STRUCTURE

The shell height data from the resource assessment surveys in 1995, 1997, 1999, 2000, 2007, 2011 and 2018 were used to determine the abundance at length in 1 mm groups determined with STRAP analysis within each of the three beds. Length frequency distributions were generated to display these results.

The shell height data was also used to calculate the average mean and mode of the shell height (mm) within each of the three beds. These results were presented in line plots to compare the trends.

The individual shell height and meat weight data from the 2018 resource assessment survey were used to conduct a linear regression of the shell heights in relation to meat weights within each of the three beds and were compared within respective linear regression plot.

RESULTS

THE FISHERY

Landings peaked in 1972, 1985, and 1994 at approximately 2,500 t each year (Figure 3). Landings have averaged less than 400 t since 2000, although the TAC was 1,000 t. Only 115 t and 127 t were landed in 2017 and 2018, respectively (Figure 3). Since 2000, with the exception of 2004, over 85–90% of the landings have come from Bed 3. An example of this distribution in fishing effort is shown in Figure 4 from 2010–18.

Commercial catch per unit of effort (CPUE) indicates that fishery performance has improved since 2002 (Figure 3). Since 2002, the average CPUE has been approximately 45 kg/tow and reached its highest level at 59 kg/tow in 2018. During this period, the number of active licenses has fluctuated between 26 in 2006 and six in 2018 (Table 1).

BIOMASS AND ABUNDANCE

The resource assessment in 2018 resulted in an MDB estimate of 3,432 t in all beds combined (Figure 5, Table 2). This MDB has declined from 5,748 t in 2007 to 4,123 t in 2011 and 3,432 t in 2018. This is a decrease of approximately 40% in the overall biomass since the 2007 survey. In the same time period, the biomass estimates in Beds 1 and 2 decreased by approximately 45% and in Bed 3 decreased by 25%.

Throughout the survey time series the MDB estimate has generally (except in 2011) been highest in Bed 1 (comprising 40–50% of the total estimate). While in Bed 3 the MDB estimates have been 30–40% of the total MDB estimate for all beds combined (Figure 6).

The abundance estimates showed a similar trend as the MDB estimate with a decrease of approximately 32% since 2007 (Figure 7).

MEAT YIELDS

The meat count and meat yield throughout the survey time series for all three beds combined showed little change (Figure 8, Table 3). However, when examining the results from the last three resource assessment surveys for each of the three beds, the meat count showed the strongest change in Bed 1, with an increase from 35 meats/500 g to 48.6 meats/500 g indicating a reduced meat yield (Figure 9). Meanwhile in Beds 2 and 3 the meat counts remained stable over the last three survey years with the lowest meat count of 25 meats/500 g in Bed 2 indicating a higher meat yield (Figure 9).

SIZE STRUCTURE

The length frequency distributions display the size structure within each of the three beds over the survey time series (Figure 10). Overall, the Iceland scallop from Bed 2 were larger in size in 2018 with the average mode shell height of 94 mm, while the Iceland scallop from Bed 1 were smaller with an average mode shell height of 89 mm (Figure 10, Table 4). In Bed 3, where most of the fishing activity occurs, the shell height has decreased in the last three survey years and the average mode shell height was 87 mm in 2018, while the meat count increased again indicating a decrease in the meat yield (i.e., smaller meats).

The mean shell height (mm) over the survey time series for each of the three beds showed a slight increase in Beds 1 and 2 and a slight decrease in Bed 3 (Figure 11). Overall the mean shell height was consistently highest in Bed 2 (Figure 11).

Iceland scallops recruit to the exploitable biomass at approximately seven years of age (approx. 60 mm). Over the survey time series there has been no sign of recruitment to the exploitable biomass; as shown in Figure 11 the lowest mean shell height in all three beds is close to 85 mm (DFO 2009) . This could be related to the type of gear that is utilized combined with the substrate type (i.e., bedrock and large stone). The ring size and configuration of the dredge may not effectively capture smaller size scallop that could potentially be located within the crevices of the large boulders and stone.

The linear regression of shell height to meat weights from scallop sampled in each of the three beds during the 2018 survey showed that the scallop in Bed 2 were larger than the scallop sampled in Beds 1 and 3 (Figure 12).

NATURAL MORTALITY

Natural mortality rates were higher throughout the survey time series in Bed 1 and Bed 2 (Figure 13, Table 5). Over the survey time series natural mortality estimates varied without trend and averaged 0.20 in Bed 1, 0.31 in Bed 2, and 0.09 in Bed 3. The natural mortality estimate for all beds combined was 0.26 in 2018, representing the highest estimate in the survey time series (Figure 13).

PREDATION

Biomass estimates of *Leptasterias polaris*, a predatory starfish of Iceland scallop, has changed little over the survey time series (Figure 14). However, densities of starfish were higher in Beds 1 and 2 (northern beds) than in Bed 3, as were the natural mortality rates of Iceland scallop.

CONCLUSION

Landings of Iceland scallop from the Strait of Belle Isle in 2018 were at a time series low of 129 t. The MDB estimate has declined from 5,748 t in 2007 to 4,123 t and 3,432 t in 2011 and 2018, respectively. This is largely due to a decrease by approximately 45% in the MDB estimates in Bed 1 and Bed 2.

Natural mortality rates varied without trend and were higher in Beds 1 and 2 than in Bed 3, where majority of the fishing activity has taken place over the time series.

There is currently no established reference points by which to determine stock status in relation to a Precautionary Approach Framework.

REFERENCES CITED

Cochran, W.G. 1977. Sampling Techniques. Third Edition. John Wiley & Sons, Toronto. 428 p.

DFO. 2001. Iceland Scallop in Newfoundland and Labrador. DFP Science Stock Status Report C2-07 (2001).

DFO. 2009. An Assessment of the Iceland Scallop (*Chlamys islandica*) Resource in the Strait of Belle Isle and the Lilly Carson Canyons. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/043.

DFO. 2016. Integrated Fisheries Management Plan Scallop, Newfoundland and Labrador Region. March 14, 2016.

Dickie, L.M. 1955. Fluctuations in abundance of the giant scallop, *Placopecten magellanicus*, (Gmelin), in the Digby area of the Bay of Fundy. J. Fish. Res. Boar. Can. 12:707-856.

Mercer, M.C. 1974. Natural mortality of the Iceland scallop (*Chlamys islandica*) in the Gulf of St. Lawrence. ICES C.M. 1974/K7. 11p.

Naidu, K.S. 1988. Estimating Mortality Rates in the Iceland Scallop, (*Chlamys islandica* O.F. Muller). J. Shell. Res. 7(1):61–71.

Smith, S.J. and G.D. Somerton. 1981. STRAP: A user-oriented computer analysis system for groundfish research trawl survey data. Can. Tech. Rep. Fish. Aquat. Sci. 1030: iv + 66p.

TABLES

Table 1: Summary of total allowable catches (TACs), removals, and effort for Strait of Belle Isle (NAFO Division 4R), 1969–2001.

Year	TAC (t, round)	Removals (t, round)	No. of active licenses	Effort (boat days)	CPUE (kg/tow)
1969	-	248	-	-	-
1970	-	192	-	-	-
1971	-	167	-	-	-
1972	-	2,596	-	-	-
1973	-	2,189	-	-	-
1974	-	244	24	269	-
1975	-	-	-	-	-
1976	-	-	-	-	-
1977	-	-	-	-	-
1978	-	-	-	-	-
1979	-	450	16	459	-
1980	-	1,133	14	774	-
1981	-	1,530	24	1,262	-
1982	-	349	24	413	-
1983	-	371	23	485	-
1984	-	1,523	46	1,272	-
1985	-	2,546	107	2,887	-
1986	-	1,942	88	2,270	-
1987	-	1,141	57	n/a	-
1988	-	447	30	n/a	-
1989	-	155	14	n/a	-
1990	-	88	11	n/a	-
1991	-	457	24	n/a	-
1992	-	1,296	72	n/a	-
1993	-	2,122	71	n/a	-
1994	-	2,294	80	2,769	34.5
1995	-	1,497	43	2,113	28.6
1996	1,200	1,204	46	1,385	32.2
1997	1,200	1,205	45	1,313	34
1998	930	1,348	41	1,364	33.6
1999	1,100	1,058	42	1,177	29.9
2000	1,100	1,083	32	1,458	26.6
2001	1,000	638	22	731	33.5

Table 1 continued: Summary of TACs, removals and effort for Strait of Belle Isle (NAFO Division 4R), 2002-18.

Year	TAC (t, round)	Removals (t, round)	No. of active licenses	Effort (boat days)	CPUE (kg/tow)
2002	1,000	249	13	301	29.1
2003	1,000	268	17	289	30
2004	1,000	338	13	349	35.8
2005	1,000	442	18	515	39.1
2006	1,000	647	26	701	38.9
2007	1,000	282	13	309	42.9
2008	1,000	111	8	101	52.0
2009	1,000	246	13	269	48.2
2010	1,000	244	11	261	48.5
2011	1,000	431	11	266	56.4
2012	1,000	296	16	263	48.3
2013	1,000	378	12	341	50.1
2014	1,000	311	12	303	45.0
2015	1,000	200	10	179	49.5
2016	1,000	192	10	198	46.2
2017	1,000	115	8	85	47.0
2018	1,000	127	6	87	58.5

Table 2: Estimates of minimum dredgeable biomass (MDB, tonnes) of Iceland scallop in each of the three beds and transmission link in the Strait of Belle Isle from 1995 to 2018.

Year	Stratum/Area	Area	No. of Sets	Mean weight (kg) per tow	Total Wgt. (t, round)
1995-Refugium	1	252.5	30	6.74	2,585.75
-	2	134	18	8.96	1,824.24
-	3	251.9	32	4.40	1,686.56
-	-	-	-	-	6,096.54
1997	1	252.5	37	3.86	1,479.86
-	2	134	14	4.57	929.83
-	3	251.9	33	2.06	790.63
-	-	-	-	-	3,200.32
1999	1	252.5	22	17.35	6,657.75
-	2	134	14	12.70	2,585.80
-	3	251.9	42	2.77	1,060.63
-	-	-	-	-	10,304.19
2000	1	252.5	26	4.08	1,567.14
-	2	134	13	5.26	1,070.77
-	3	251.9	24	2.57	983.74
-	-	-	-	-	3,621.64
2007	1	252.5	39	7.19	2,758.04
-	2	134	30	7.04	1,434.16
-	3	251.9	39	4.07	1,556.54
-	-	-	-	-	5,748.74
2011	1	252.5	49	4.12	1,582.64
-	2	134	27	4.65	946.84
-	3	251.9	49	4.16	1,593.88
-	-	-	-	-	4,123.36
2018-Transmission Link	1	252.5	50	3.95	1,516.44
-	2	134	42	3.67	747.97
-	3	243.83	43	3.15	1,168.27
-	-	-	-	-	3,432.68

Table 3: Biological meat yields, average meat weights and meat counts of Iceland scallop in the Strait of Belle Isle in 1995, 1997, 1999-2000, 2007, 2011, and 2018.

Year	N	Round wt. (kg)	Meat wt. (kg)	Mean wt. (g)	#/lb	#/500 g	Yield (%)
1995	921	105.3	10.79	11.7	39	43	10.3
1997	555	68.7	8.77	15.8	29	32	12.8
1999	444	58	7.22	16.3	28	31	12.4
2000	537	64.9	7.95	14.8	31	34	12.2
2007	755	94.8	12.11	16	28	31	12.8
2011	428	50.4	6.324	12.5	31	34	12.5
2018	446	56.9	6.956	15.6	29	32	12.2

Table 4: Mean and modal shell heights (mm) of the Iceland scallop in each of the beds in the Strait of Belle Isle, 1995-2018.

Year	Bed	Mean (mm)	Mode (mm)
1995	1	87.2	90.0
-	2	90.4	92.0
-	3	82.0	85.0
1997	1	87.3	87.0
-	2	91.9	99.0
-	3	86.7	80.0
1999	1	86.4	90.0
-	2	90.8	95.0
-	3	89.6	90.0
2000	1	88.0	90.0
-	2	93.2	95.0
-	3	91.0	90.0
2007	1	90.4	90.0
-	2	94.9	95.0
-	3	91.3	90.0
2011	1	88.8	87.0
-	2	93.0	90.0
-	3	89.7	87.0
2018	1	91.1	90.0
-	2	96.0	95.0
-	3	89.0	90.0

Table 5: Natural mortality estimates for each of the three beds in the Strait of Belle Isle over the survey time series.

Year	Bed	Live Scallop	Cluckers	Mortality
1995	1	1,470	141	0.18
-	2	752	119	0.28
-	3	888	61	0.14
1997	1	1,283	64	0.1
-	2	478	92	0.33
-	3	647	19	0.06
1999	1	2,381	178	0.15
-	2	1,196	182	0.28
-	3	953	39	0.08
2000	1	939	101	0.2
-	2	513	94	0.32
-	3	510	28	0.11
2007	1	2,304	210	0.18
-	2	1,448	174	0.22
-	3	1,353	58	0.09
2011	1	2,174	285	0.25
-	2	1,365	339	0.41
-	3	1,927	62	0.07
2018	1	1,782	333	0.32
-	2	1,164	245	0.36
-	3	1,478	61	0.09

FIGURES

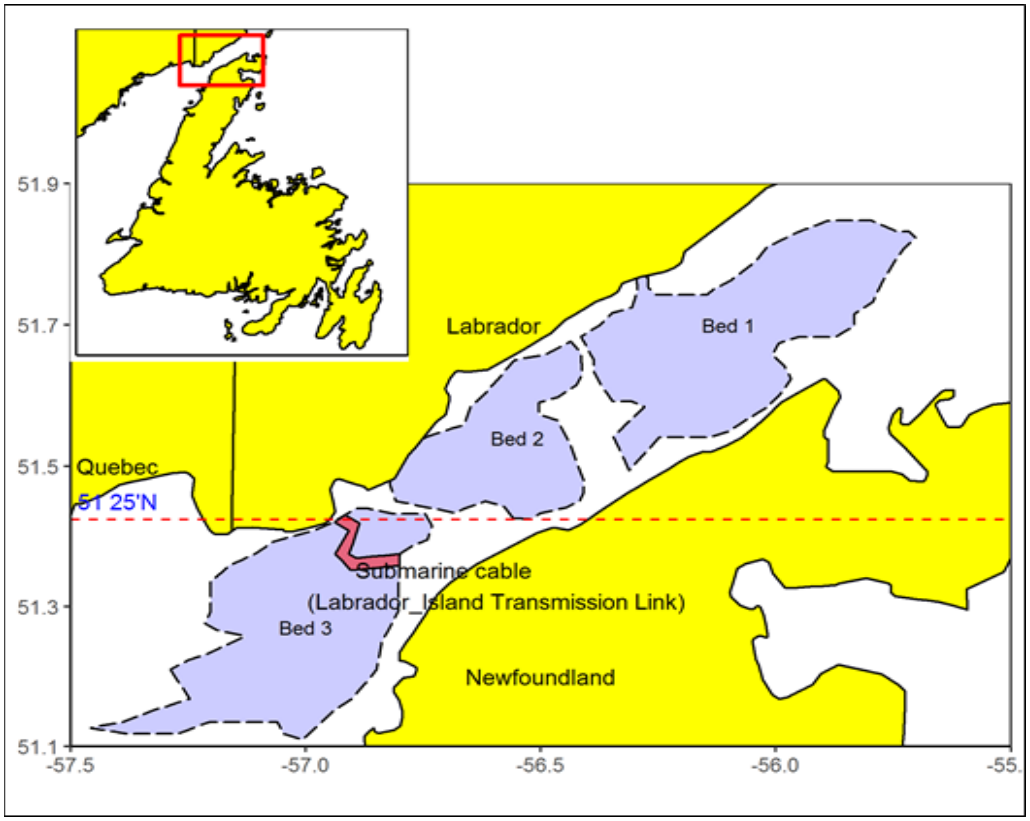

Figure 1: Map of the scallop fishing area in the Strait of Belle Isle, including the three scallop beds, the submarine cable (highlighted red polygon) (established in 2014), and 51°25' North latitude line (dashed red line). Map of Newfoundland and Labrador showing the scallop fishing area in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R) (inset).

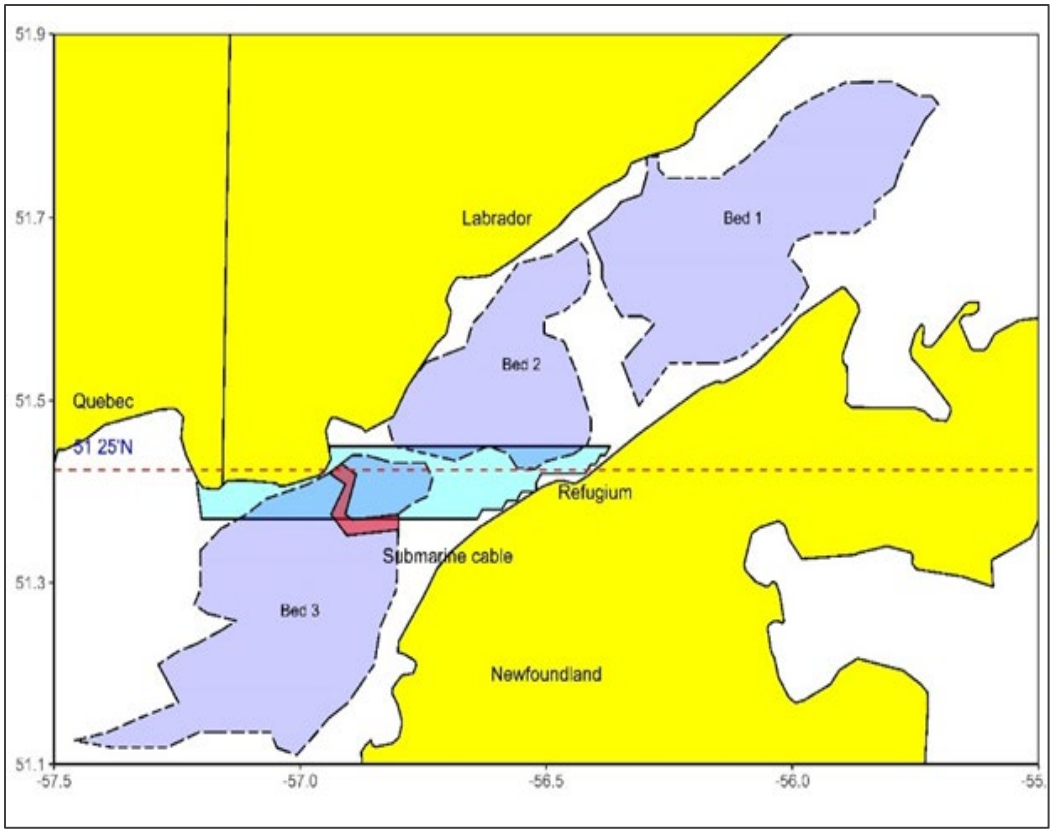

Figure 2: Map of the scallop fishing areas in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R), including the refugium (highlighted light blue) (2000–09), the submarine cable (highlighted red) (established in 2014) and 51°25' North latitudinal line (dashed line).

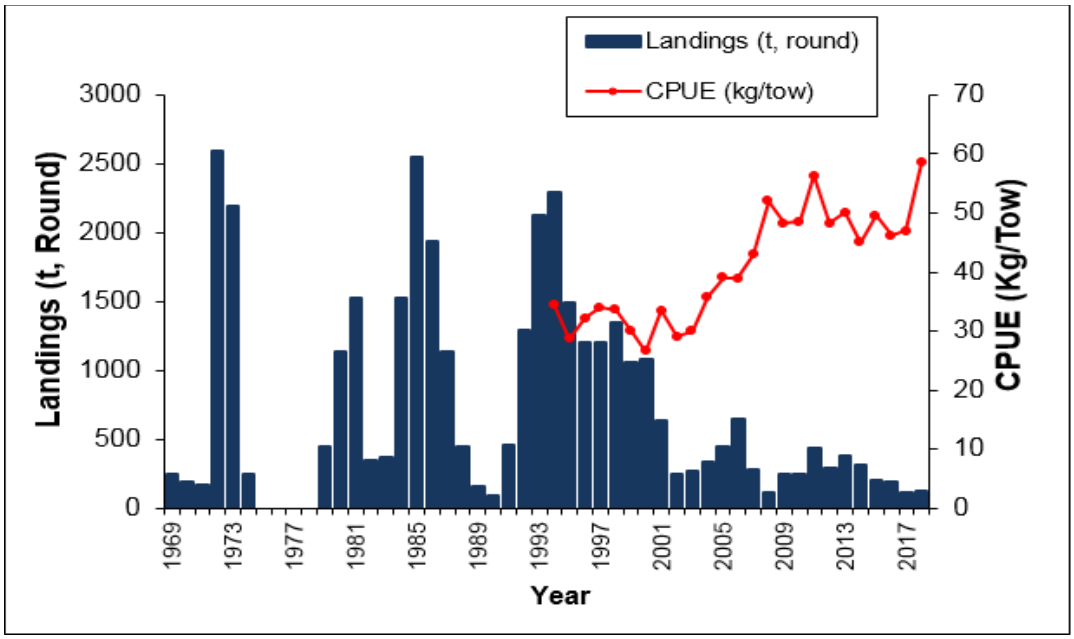

Figure 3: Landings (t) of Iceland scallop from the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R), 1969–2018 (solid bar graph). Trends in Strait of Belle Isle commercial CPUE (kg/tow) (red line), 1994–2018.

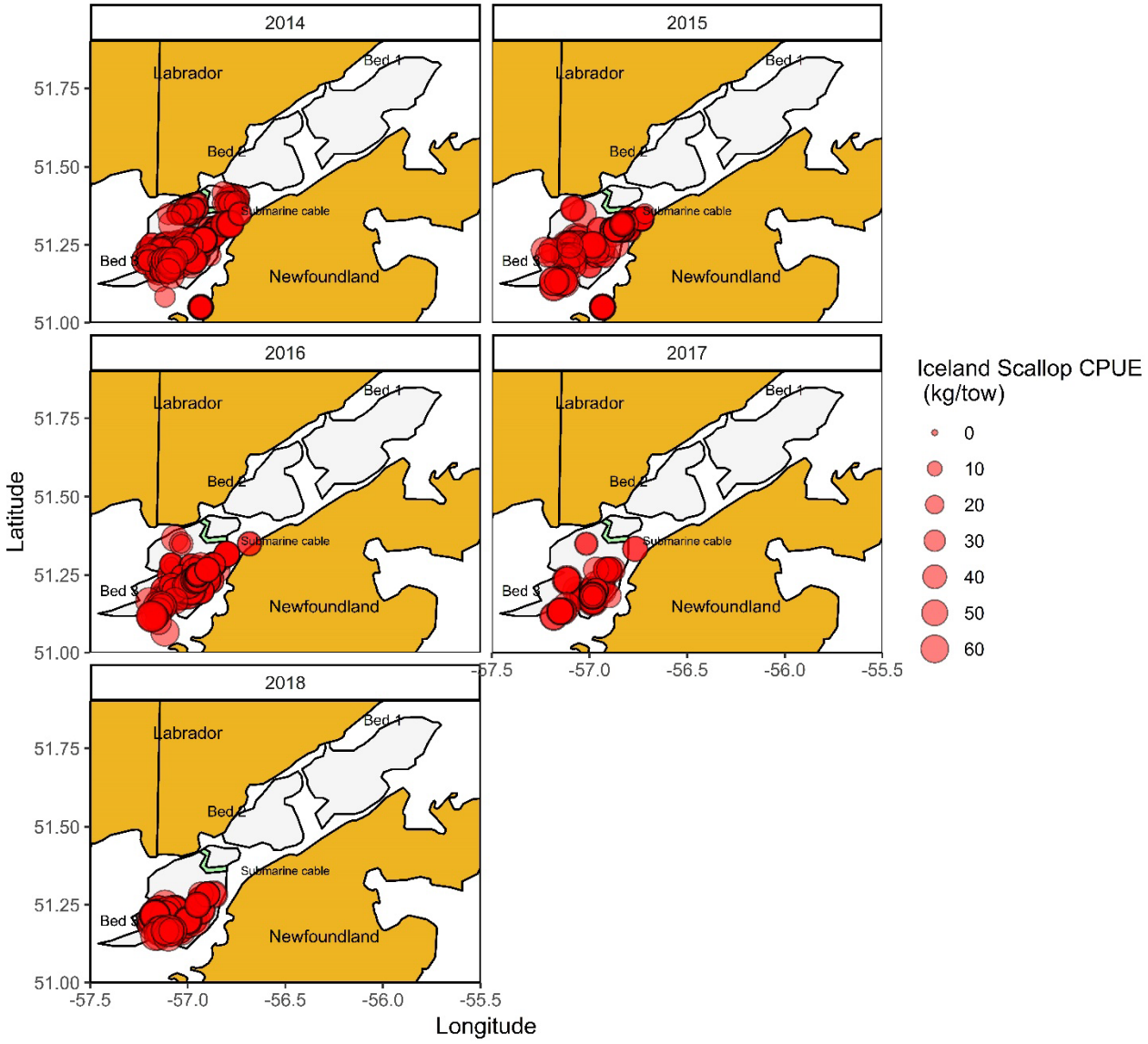

Figure 4: Distribution of the commercial CPUE (kg/tow) of Iceland scallop from the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R), from 2014–18.

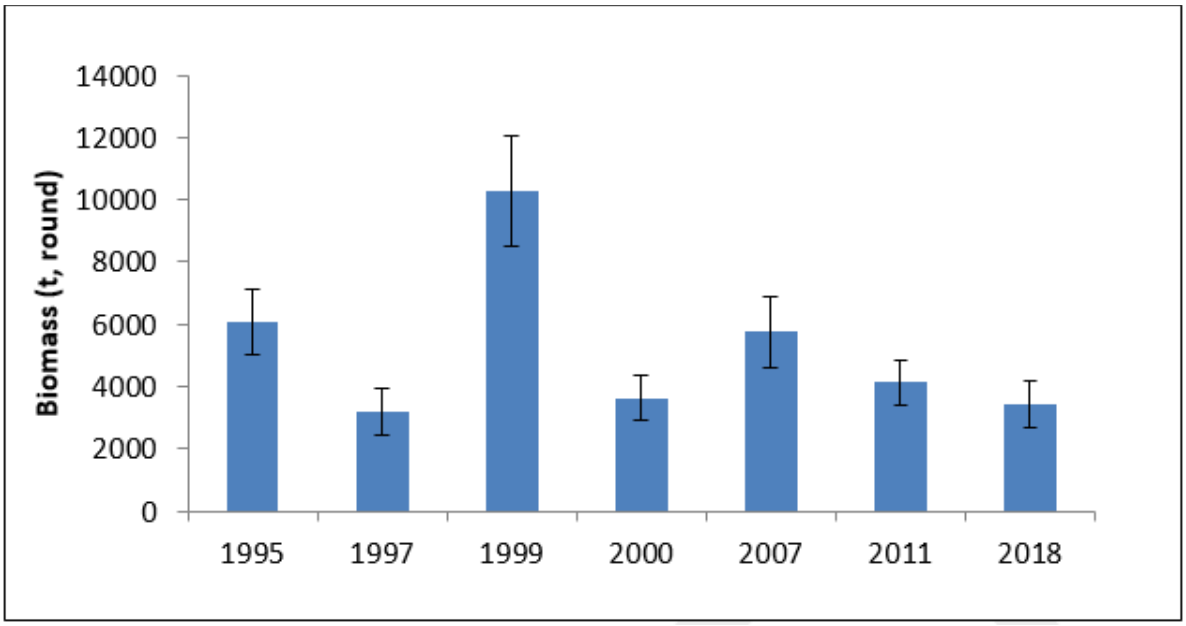

Figure 5: Minimum dredgeable biomass (MDB) estimates (with 95% CI) for Iceland scallop in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R).

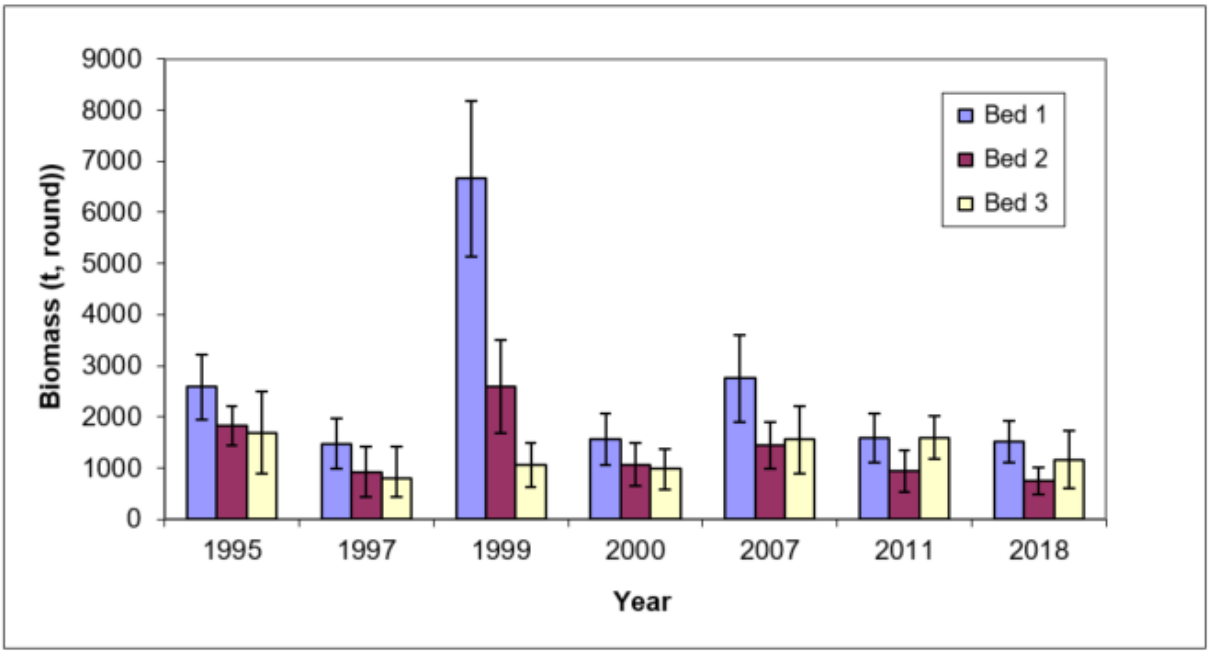

Figure 6: MDB estimates (with 95% CI) for Iceland scallop in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R), by bed.

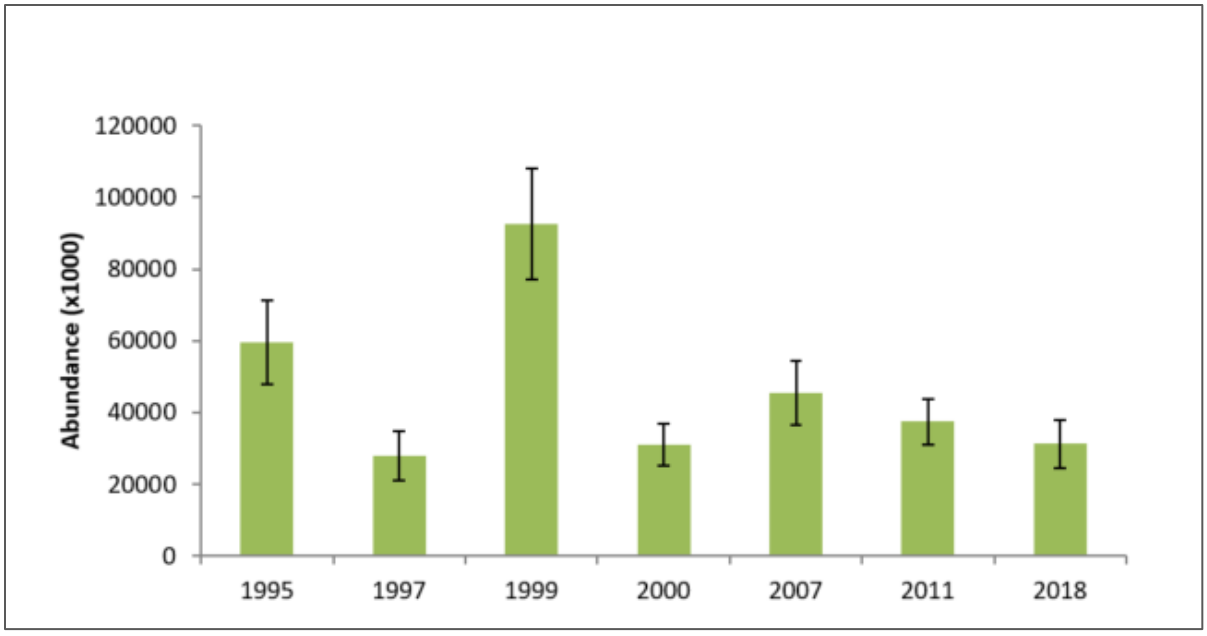

Figure 7: Abundance (1,000s) estimates (with 95% CIs) for Iceland scallop in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R).

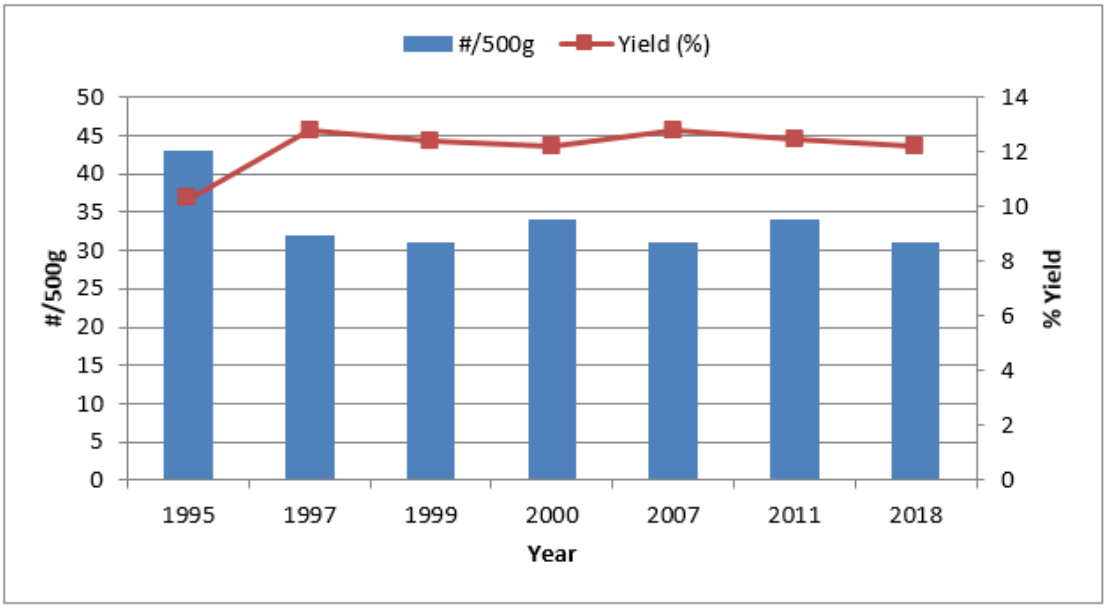

Figure 8: The meat count (#/500 g) and meat yield (%) of Iceland scallop throughout the survey time series for all three beds in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R).

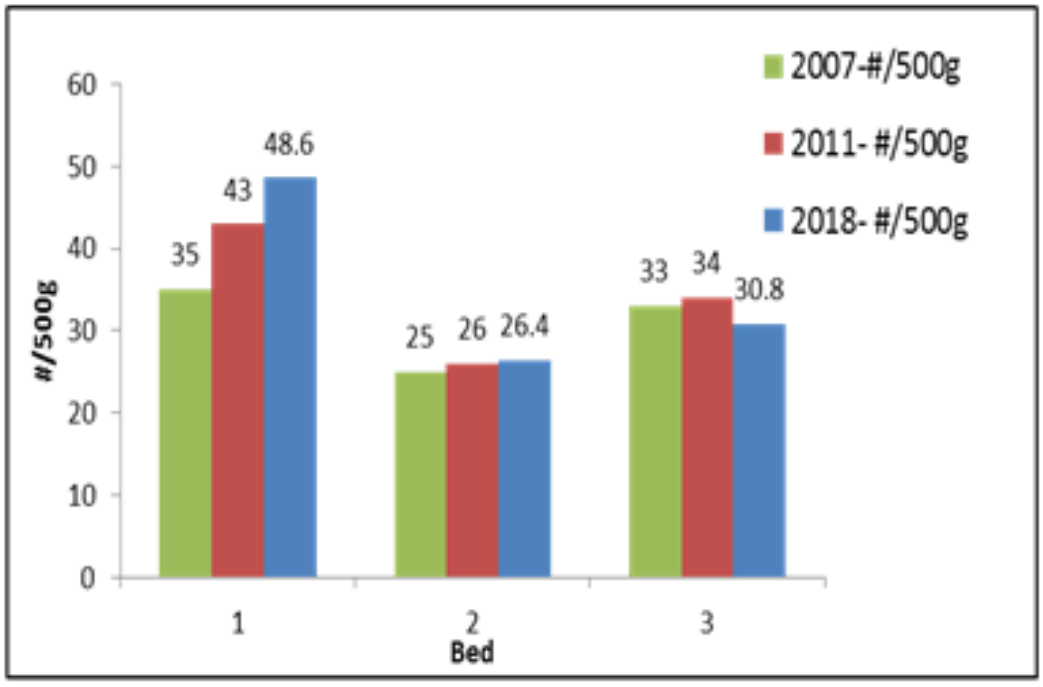

Figure 9: The meat count (#/500 g) in each of the three beds from the last three surveys in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R).

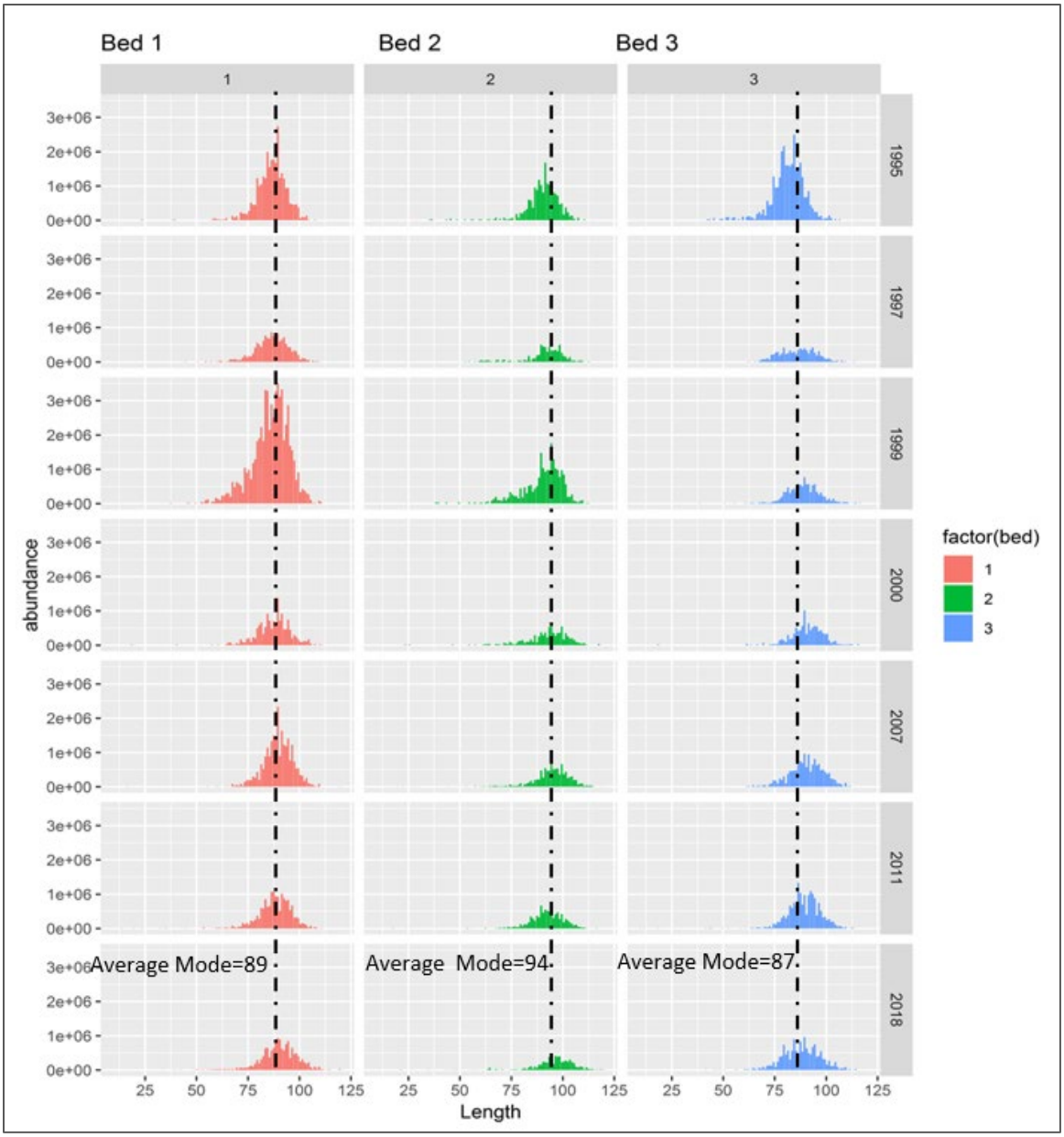

Figure 10: Length (shell height, mm) frequencies of Iceland scallop, showing abundance at shell height (from STRAP analysis) for each of the three beds in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R) over the survey time series. Black vertical dashed line represents the average mode within each bed.

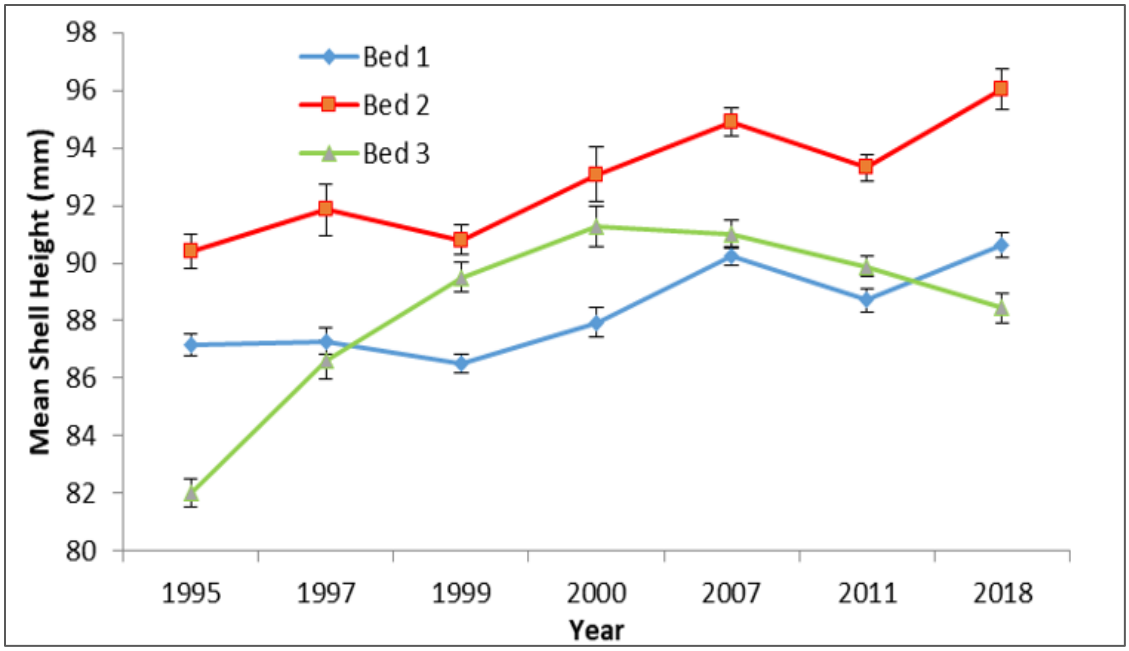

Figure 11: The mean shell height (mm) of Iceland scallop from each of the three beds in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R) over the survey time series.

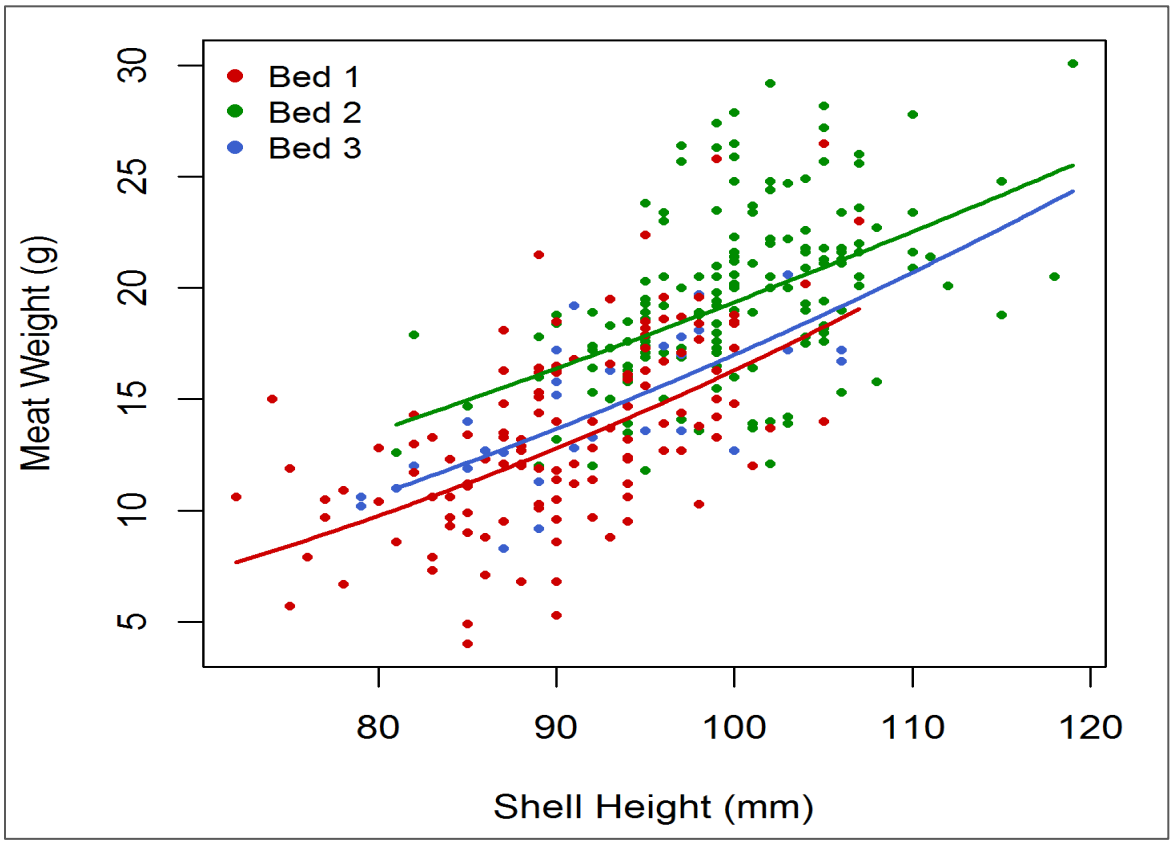

Figure 12: Linear regression of the shell heights to meat weights of Iceland scallop within each of the three beds in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R) (from 2018 resource assessment survey data).

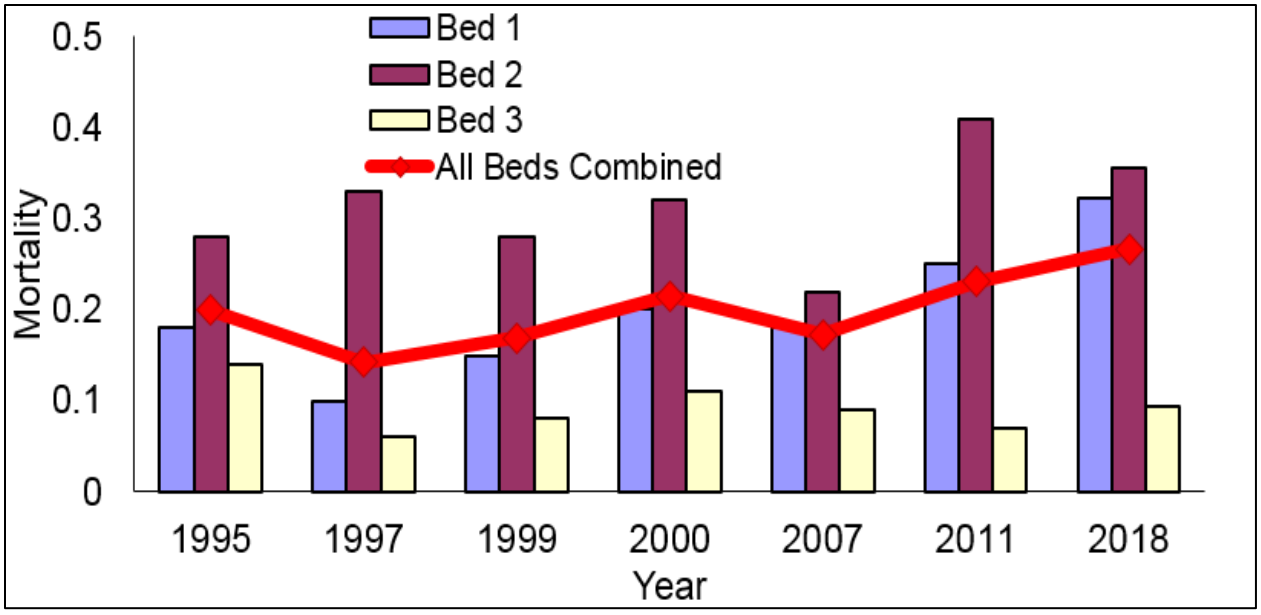

Figure 13: Natural mortality estimates for Iceland scallop in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R) in each of the three beds and for all three beds combined (red line) over the survey time series.

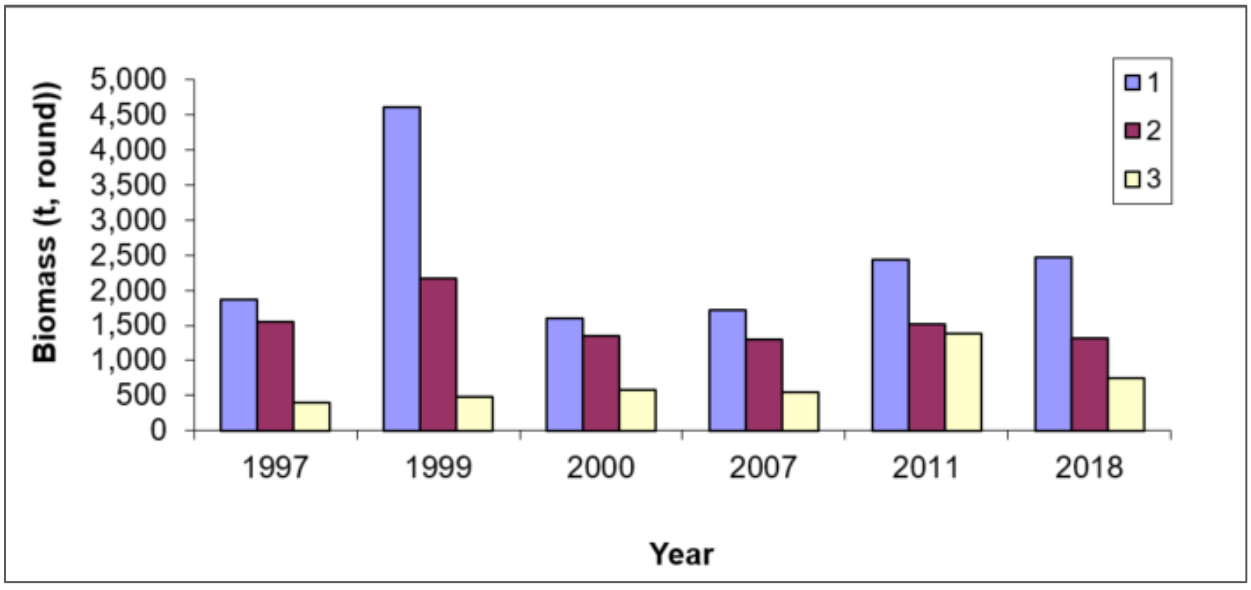

Figure 14: MDB estimates for Leptasterias polaris in the Strait of Belle Isle (Scallop Fishing Area 14A, Division. 4R) for each of the three beds over the survey times series.