BIOMASS OF NORTHERN SHRIMP (*Pandalus borealis*) AND STRIPED SHRIMP (*Pandalus montagui*) IN SHRIMP FISHING AREA 2

Context

In March 2008, Fisheries and Oceans Canada (DFO) Science assessed the status of shrimp stocks in Shrimp Fishing Areas (SFA) 0, 2 and 3 (DFO 2008). SFA2 was not assessed in its entirety but based on two survey study areas; SFA 2 Exploratory (SFA2EX: SFA2 east of 63°W and north of 63°N), and the Resolution Island Study Area (RISA: 66°W-63°W and 60°30'N-63°N) (Figure 1). SFA2 includes SFA2EX and the eastern half of RISA west of 63°W, east of 64°30'W, which corresponds to SFA2 Commercial (SFA2CM). Two species of shrimp, northern shrimp (*Pandalus borealis*) and striped shrimp (*P. montagui*), are found in SFA2. *P. borealis* is the dominant species in SFA2EX whereas both species are highly mixed in RISA.

On 17 April 2009, DFO Fisheries and Aquaculture Management (FAM) requested Science advice on the fishable and female spawning stock biomass indices for SFA2CM, SFA2EX and the whole of SFA2 (Figure 1) for both shrimp species based on the most current data available. The advice was requested to support the offshore northern shrimp license holders who are seeking Marine Stewardship Council (MSC) certification for SFAs 1, 2, 4, 5, 6 and 7. On 16 March 2009, the offshore sector requested provisional Limit Reference Points (LRP) and harvest control rules for SFA2 are in place prior to the main MSC assessment expected in the summer of 2009, as was already done for SFAs 5-7. Developing provisional LRPs for SFA2 first require estimates from SFA2 as a whole. As SFA2 has never been assessed as a whole and the next full assessment won't be undertaken until early in 2010 which is after the advice is needed, a Science Special Response Process was undertaken.

Background

SFA2EX was assessed by DFO Science at the 2008 Northern Shrimp Zonal Assessment Process (DFO 2008). The SFA2EX area has not changed since the initial survey in 2005. RISA was established in 2006 as a scientific study area. The SFA2CM area was assessed as part of RISA (DFO 2008). Some strata from the original RISA survey stratification cross the SFA2/SFA3 border in RISA. To address the current request, straddling strata have been split and new stratum areas calculated. Existing survey sets from 2006-2008 have been post-stratified using the new stratification scheme in order to determine the biomass for SFA2CM.

In 2006 and 2007, the standard Campelen 1800 trawl was used to survey RISA but encountered a high rate of tear-ups. The standard Campelen trawl was modified to reduce tear-ups and allow a more complete survey in 2008. To that end, the gear change was very successful. In 2008, there were only two tear-ups, one of which resulted from contacting the bottom while the other was blown out by the tide. In past years there have been 10 or 12 tear-ups.

The standard trawl has 35 cm rockhopper discs with the fishing line toggled tight to the discs. Modifications increased the disc diameter to 53 cm and added floats along the fishing line which raised the fishing line and bellies higher off bottom. It also made the trawl lighter and less likely to dig into the bottom. Toggle lengths were increased proportionally. Float lines were added along the side of the belly which helps hold the netting up off the bottom when the trawl is stopped. No changes were made to the netting from that used in the standard trawl. The modifications being considered were studied using scaled models of the trawl in the flume tank at the Marine Institute; St. John's, NL. The purpose of the study was to determine possible effects of the modifications on trawl geometry. The modifications did not significantly change net geometry, that is, the mouth opening was the same as the standard trawl. Therefore, no significant difference would be expected once a shrimp is in the net. The main difference was the height of the bellies off the bottom. At the first belly, the modified trawl is 24 cm higher off the bottom than the standard trawl, which could affect the catchability of the gear. Catchability could not be tested in the flume tank. In 2008, RISA was surveyed with the modified Campelen trawl. This change meant that different gears sampled the two parts of SFA2 in 2008.

The survey in RISA is a multi-species survey but focused on shrimp. Both northern shrimp (*Pandalus borealis*) and striped shrimp (*P. montagui*) are found in SFA2; however, the *P. montagui* distribution is mostly limited to the area west of 63°W. East of 63°W the species composition is predominantly *P. borealis.* Moving west, the percentage of *P. borealis* drops to approximately 50% in RISA. *P. montagui* becomes the dominant species (83%) in SFA3. The amount of exchange of shrimp across the SFA2/SFA3 border is unknown. There is some expectation that movement between the two areas occurs (e.g. tidal and seasonal) especially since the net movement of water is from SFA3 to SFA2. It is unclear whether SFA2CM is supported entirely by local production alone. The shrimp that support recruitment into that area may come from SFA2EX or SFA3 but not likely SFA4 since the net current in the area is toward the south and east. Shrimp fishing areas define "management stocks" rather than "genetic stocks". If the population is replenished from SFA2 as a whole or from SFA2 and SFA3, then maybe the area as a whole should be assessed.

Analysis

Shrimp Management Area Borders

Shrimp management areas in the north are quite complicated (Figure 1). A potential solution to management areas could be to consider RISA and SFA2EX each as separate management areas. All management areas are artificial lines but this would recognize a difference in the distribution of the species, and the different gear types used in each area. It would conserve data already collected for these areas. Realignment of the management areas is a legitimate question but Science was not asked to for advice on this question. SFA2 is the existing management unit, the basis of the question from FAM and the stock area designated by industry in their MSC Certification application.

A question arose as to how the SFA4 box (southeast corner of RISA; 61°N-60°30'N, 63°W-64°30'W) would factor into the discussions. This area is part of SFA2, as all catch caught in the box is reported in SFA2 so it has been included as part of RISA and SFA2CM. There are no implications for SFA4 and this is not redefining the management unit as this area is currently considered part of SFA2. It was suggested that maintaining ongoing reporting by the various areas would not be problematic. The plan for future assessments is to present the results for SFA2CM, SFA2EX, and the western part of RISA separately along with SFA2 in its entirety.

Post-survey Division of RISA

In order to determine the biomass from SFA2CM, the RISA survey was divided into two halves, the eastern half being SFA2CM while the western half is part of SFA3. This required a post survey re-stratification of the area. Figure 2 represents the existing stratification by depth for the RISA area for surveys conducted in 2006-2008. SFA2EX has not changed and so is not part of this re-stratification exercise. Figure 3 shows the border between SFA3 and SFA2 through the centre of RISA. The stratum name is represented by its maximum depth (first three digits) and its number (second three digits). Strata were split along the SFA2 border. In cases where small areas were orphaned by the split, they were added to a nearby stratum of the same depth range and the total area recalculated for the combined larger stratum. Arrows identify the orphans and the stratum with which they were combined. For example, the small area originally part of 300-324 extending east of the border is combined with 300-323E. Table 1 provides the original stratum number, depth, original and split areas, identifies combined strata and the final stratum areas shown in Figure 3.

The stratification changes will be used in all future surveys and is not simply being used to address the current request. The new stratification does allow the biomass to be calculated for the two areas within RISA more easily by ensuring that strata no longer cross the border between SFA2 and SFA3. It will also allow for better monitoring of the fishery since 92% of the fishing in SFA2 takes place in the SFA2CM box.

Operationally the stratification changes will have no effect on the survey design. The strata are essentially split for output of results. The survey design based on the new stratification still uses the standard approach from past surveys which allocates sets proportional to the stratum area, with the caveat that there be a minimum of two sets in each stratum. Set locations within a stratum are chosen using the Doubleday method (1981). This approach will not change. In the future, the appropriate number of sets would be allocated on each side based on areal proportion to produce the biomass estimate.

For each survey year, a new randomized set allocation is produced. Successful set locations for survey years 2008 to 2006 are shown in Figures 4, 5 and 6 respectively. Table 2 summarizes stratum areas and the number of successful sets taken each year. The proposed 2009 proportional allocation of sets, based on the scheme above, is included for comparison. The proposed set allocation for 60 sets was based on the adjusted stratum areas. This plan assumes that the 305 stratum will be dropped as successful sets have never been taken in the area during any of the three survey years. 305 is a very small stratum and the crew has requested it be dropped for safety reasons. They don't think trawlable bottom exists in the stratum and the strong tides make it very difficult to fish properly.

The post-stratification using the existing survey for 2008 has 35 sets in RISA-East compared to the 37 which would be allocated with the new stratification. There was only one set in stratum 319 but otherwise there was a good distribution of sets. The main issue on the western side is stratum 333 which had no sets and stratum 327 with only one set. The distribution becomes progressively worse when examining the 2007 and 2006 surveys. There were always fewer sets taken than allocated because of the gear and because sets were lost on re-examination of the CTD profiles or tear-up coding issues. CTD profiles indicated the trawl was not reaching the bottom because of poor trawl monitoring equipment which happened more often in 2006 than 2007. In 2006, there was less then half the number of sets taken than were allocated. Biomass from the 2006 and 2007 surveys is more questionable and conclusions from the last assessment (DFO 2008) were that the uncertainties precluded providing advice.

There was some discussion about whether the approach taken would result in lower confidence intervals. It was felt that this is not likely to be the case since the distribution of shrimp in the area is very patchy and often results in high confidence intervals. In 2006 and 2007, the incomplete surveys are problematic. The survey in 2008 with the modified gear is the best survey so far in the area and the re-stratification worked out reasonably well.

Participants asked about whether other approaches had been considered. In Newfoundland, when there was a change from the Engels to the Campelen nets an extensive multi-year study was conducted comparing the two trawls in side-by-side trials before conversion factors were estimated but only for groundfish species. This approach is appropriate for shrimp. Another approach is to derive conversion factors based on comparisons of ratios for three years prior to and following gear changes and this has been used for some species. This approach assumes that any changes in catch rates can be attributed to the gear change and is likely more appropriate for long-lived and lightly or un-exploited species. Given the short life-span of shrimp, this method of determining conversion factors is less desirable and could yield erroneous results.

Participants asked for a comparison of sets for 2007 and 2008 that were reasonably close to see if there were large differences. Participants questioned whether the differences in the estimates may be due to untrawlable areas from 2006 and 2007 that were now able to be trawled because of the new gear as opposed to differences in the efficiency of the net. This comparison however assumes little change in distribution and abundance which is not likely to be the case. In 2006 and 2007, the standard Campelen gear was used and any sets lost out of the allocation were due to tear-ups or not being on bottom or not completing the sets. In 2008, a procedure was implemented to remove un-trawlable bottom, represented by the blacked out boxes from the survey areas (Figure 4). There was a coding change when it was found that some sets were being considered successful (minor tear-up) even though one, two or three bellies were torn out. Some of those sets were excluded after the survey. Steps have been taken to address this in the upcoming survey. The determination of whether or not it is possible to trawl is made on the ship by the Captain and scientist-in-charge.

Concern was raised as to whether the proportion of sets from combined strata were sufficiently different to cause bias in biomass estimates in these combined strata. This analysis was completed and results circulated to the group following the call. There were only three strata in RISA-East where portions were combined into a new larger strata; 316E & 333E, 323E & 324E and 326E & 327E. The portion of 327E added to 326E was very small in area and contains only 2 sample cells and is therefore not a concern. With the same proportional allocation from the larger stratum one would expect two sets allocated to 333E and three were taken in 2008. For 327E, one set would have been allocated and one was taken. These differences were considered small and therefore of no concern in combining the strata.

An alternate procedure to determining biomass of RISA-East and RISA-West was suggested where the mean weight of shrimp in the straddling strata would be applied to the areas of the split strata east and west of the SFA2 border, based on the 2008 survey data. This analysis was done following the call and distributed to the group. There was little difference between the two procedures overall for *P. borealis* with a difference of only 774 t. *P. montagui* shows a greater difference at 2197 t. Within an area, the differences between the two procedures were much greater; 180 t for *P. borealis* but 2851 t for *P. montagui* within RISA-East. Within RISA-West the difference for both species was in the 600 t range. It is the direction of the change however which is more striking. The higher value is reversed between the two procedures. This alternate procedure assumes an even distribution across the stratum east to west and masks any distributional differences in the two species believed to occur in RISA.

It was suggested that Ogive Mapping (Ogmap) (Evans *et al.* 2000) might be used to estimate biomass. This will be done for future ZAPs. Ogmap is expected to produce a final biomass estimates similar to the areal expansion methods used here. The group agreed to accept the restratification of RISA (Figure 3).

Biomass Estimate for SFA2CM

Fishable biomass (Figure 7) and female spawning stock biomass (Figure 7) for *P. borealis* show a marked increase on the western side of RISA in 2008 but little change in the east. For *P. montagui* (Figure 8) there was a large increase in eastern RISA. The difference for the two species reflects distributional differences across the study area consistent with temperature regimes found in the area. It cannot be determined whether the overall increase in biomass is a result of the use of the modified gear in the 2008 survey or if it was a year effect, that is, greater biomass in the area in 2008 or simply a function of the most complete survey to date. This will have to be followed as the time series with the modified gear builds in the coming years.

There was some discussion about the error bars and the differences between years. The error bars were as wide as or wider in 2008 than previous years. As there are more successful sets, the probability of hitting a large patch goes up which drives the variance. Fishable biomass (Table 3) is presented for the sub-areas (RISA-East and RISA-West) for each year, with the sum of the splits (split total) and the total from the whole RISA survey area based on the original stratification. In most years, there is not a large change between the two approaches. However, there is more of a difference in 2006 for *P. borealis*; 10,019 t split total versus 13,259 t whole total, and for *P. montagui*; 2,702 t split total versus 7,997 t whole total. Results for female spawning stock biomass (Table 4) follow a similar pattern. The information allows a different look at the biomasses likely due to the different distribution of the two species in the areas.

Participants asked whether catchability was expected to be higher or lower with the modified gear. From flume tank tests of the models, the net geometry of the modified trawl was not significantly different from the standard Campelen. Therefore, shrimp entering the net mouth of either trawl would be expected to be caught with the same efficiency. The main difference was that the modified trawl rides higher above the bottom (24 cm). If shrimp are tight to the bottom then some portion might be missed by the modified trawl. If shrimp were higher off the bottom the modified trawl might be into the denser part of the population and perhaps might have a higher catch. It was noted that the Marine Institute had conducted tests of shrimp in the water column that showed a significantly higher proportion of shrimp are caught in the bottom 1/3 of the net suggesting that the gear change for this survey may have the effect of reducing the catchability of the net. Without side-by-side testing there is no way of knowing what the difference is and it cannot be determined from the information available. While the differences cannot be quantified it is expected that the differences in catchability between the two gears would not be large.

Total Biomass for SFA2

SFA2 has two separate TACs applied to the area 5,250 t for SFA2CM and 3,500 t for SFA2EX. SFA2CM has produced an annual catch at or near the TAC while in SFA2EX generally only a small portion of the TAC is taken (212 t in 2008). The observed biomass shows the exact opposite with 11,300 t in SFA2CM and 36,341 t in SFA2EX for a combined total of 47,641 t. The interpretation of the results of the surveys depends on whether the two parts of SFA2 are

viewed separately or are combined. Exploitation rates are greatly affected when viewing the combined biomass. Combining the two areas effectively quadrupled the biomass and results in considerably reduced exploitation rate estimates (Tables 5 and 6, Figures 9 and 10). Obviously the two areas can be combined mathematically but the real question is whether they should be scientifically?

Simple summing of the two areas would result in biomass estimates from two different gears in two separate study areas being combined into a single estimate. Concerns were expressed based on trawl standardization protocols developed for DFO surveys (S. Walsh DFO-NL and ICES working groups) and under which this Industry-DFO survey operates. Based on this protocol, the modified gear used in RISA constitutes a major change in the survey which would require an inter-calibration if the data was to be considered equivalent in a time series (ICES 2006).

Concerns were expressed about whether it was appropriate to combine the SFA2EX area and the RISA area without understanding q (trawl catchability). Discussion of catchability centered on how much impact the gear change might have had on the biomass estimates. Most thought that the modifications to the gear would have a small effect but it was agreed that there is no way of knowing exactly how much of an effect it had. It was suggested that the increased biomass observed in 2008 may be a result of having better surveys. Even using the same gear, having completed more sets, an increase in biomass might be expected. From that perspective, the data sets could be combined from the different gear with the rationale being that the increase in biomass results to a larger extent from increased survey coverage than from the difference in gear. Biomass indices doubled or tripled in three of four panels in Figure 8 and although this may be because of better coverage and completion of more sets, there was some concern it could be related to trawl catchability.

Concerns were expressed whether combining the two areas because of the gear differences would mean only being able to provide advice in the future when the whole area is surveyed with the same gear. The group agreed that if the survey was started with current knowledge that the modified gear would have been used for the entire survey area. It was suggested that it would be appropriate to use the same net in the future across the whole of SFA2 so that there would be no concern with a gear effect going forward. It was pointed out that the existing surveys represent the best available information of the shrimp populations in the area despite the issues associated with the survey. It was agreed that past survey information could be combined and presented as long as the issues around combining the two areas are clearly presented in text and graphics

Further discussion focused on how best to present the information by clearly identifying in the text and graphs using dotted lines or different symbols and including what the implications of this would be. From a management perspective it has to be clear that there has been the change to the gear in 2008. The 2008 survey is considered to be better because of less gear damage and a higher number of sets completed. Because of the modifications to the trawl, it should be clear going forward that the data for 2006 and 2007 may not be directly comparable to that of 2008 and trend lines should not include different gears.

Tables 5 and 6 and Figures 9 and 10 clearly identify the breaks where gear changes have occurred while preserving the information collected in past surveys.

Conclusions

Based on discussions at the meeting, participants agreed that a re-stratification of the RISA area was needed to allow estimation of a biomass index in SFA2. Alternate approaches were considered but the methodology used was found to be reasonable and better represented distributional patterns of the two shrimp species in the area.

The surveys in 2007 and especially 2006 were conducted with the same gear as SFA2EX and so could be combined in these years to produce a biomass estimate for the whole SFA2. However, there are other significant survey issues within the RISA portion of SFA2 which makes drawing conclusions from them uncertain. For the 2008 survey, it was concluded that, despite the differences in the gear types used, a single estimate would also be produced as long as the issues around combining the two areas are clearly presented in text and graphics. The modified gear will be used in future surveys in SFA2EX and RISA thus eliminating the issue of gear type.

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Sources of information

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Appendices

Table 1: Stratum Areas: Original strata were split along the SFA2 border, area of each portion determined then recombined to produce the final strata in RISA corresponding to West (SFA3) and East (SFA2).

Original Stratum Number	Stratum Depth (m)	2006-2008 Stratum Area (km^2)	Split Stratum Number	Split Stratum Area (km^2)	Combining Strata	Final Stratum Number	Final Stratum Area (km^2)
305	200-300	370.5	305E	58.1		305E	58.1
			305W	312.4		305W	312.4
306	200-300	178.3	306W	178.3		306W	178.3
322	200-300	1622.9	322W	1622.9		322W	1993.1
323	200-300	1383.8	323E	1013.6		323E	1034.7
			323W	370.2	add 323W to 322W		
324	200-300	1533.7	324E	21.1	add 324E to 323E		
			324W	1512.6		324W	1512.6
328	200-300	2620.0	328E	1933.1		328E	1933.1
			328W	686.9		328W	686.9
307	300-400	2066.1	307E	1446.4		307E	1446.4
			307W	619.7		307W	619.7
320	300-400	1366.0	320E	946.1		320E	946.1
			320W	419.9	add 320W to 321W		
321	300-400	780.8	321W	780.8		321W	1200.7
326	300-400	1237.9	326E	1237.9		326E	1452.9
327	300-400	822.5	327E	215.0	add 327E to 326E		
			327W	607.5		327W	607.5
316	400-500	1756.7	316E	1756.7		316E	2260.7
332	400-500	1714.2	332E	1714.2		332E	1714.2
333	400-500	1583.4	333E	504.0	add 333E to 316E		
			333W	1079.4		333W	1079.4
317	500-600	800.3	317E	800.3		317E	800.3
318	500-600	829.0	318E	829.0		318E	829.0
319	500-600	789.9	319E	789.9		319E	789.9
331	500-600	863.8	331E	863.8		331E	863.8
308	500-750	1444.8	308W	1444.8		308W	1444.8
Total		23764.6		23764.6			23764.6

Table 2: Successful sets taken per stratum over the three years of the RISA survey based on the new stratification. The suggested 2009 proportional allocation of sets based on the adjusted stratum areas is included for comparison to past surveys sets taken within each stratum. Adjusted area accounts for cells removed from the survey in 2008 which were deemed untrawlable.

RISA Zone	Stratum	Adjusted Stratum Area (km^2)	2009 Proportional Allocation (min 2 sets/stratum)	2008 Sets Count	2007 Sets Count	2006 Sets Count
East	305E	Drop		0	0	0
East	307E	1446.4	4	3	1	0
East	316E	2260.7	6	9	6	2
East	317E	800.3	2	2	2	2
East	318E	829.0	2	2	2	1
East	319E	789.9	2	1	2	2
East	320E	946.1	3	3	2	2
East	323E	926.7	2	2	2	0
East	326E	1452.9	4	4	4	3
East	328E	1933.1	5	3	3	2
East	331E	863.8	2	2	2	2
East	332E	1714.2	5	4	4	1
Total		**13963.1**	**37**	**35**	**30**	**17**
West	305W	Drop		0	0	0
West	306W	178.3	2	2	2	2
West	307W	619.7	2	2	3	2
West	308W	1444.8	4	2	3	0
West	321W	840.7	2	2	2	2
West	322W	1624.1	4	4	2	2
West	324W	864.6	2	2	2	1
West	327W	607.5	2	1	1	2
West	328W	686.9	2	3	2	1
West	333W	1070.4	3	0	0	1
Total		**7937.0**	**23**	**18**	**17**	**13**
Grand Total		**21900.1**		**53**	**47**	**30**
Sets Allocated			**60**	**59**	**59**	**55**

Table 3: Fishable biomass estimates for both *Pandalus borealis* and *P. montagui* for each of the two subareas of RISA as well as the total for the two subareas. The 'Whole Total' row is the biomass based on the original RISA stratification included for comparison.

	Fishable Biomass (OCL>=17mm)					
	Pandalus borealis			*Pandalus montagui*		
Area	Area Wt (t)	LCL	UCL	Area Wt (t)	LCL	UCL
2008 RISA-East	11,300	1,477	27,115	8,393	3,015	13,936
2008 RISA-West	4,008	1,647	6,389	5,499	2,596	8,401
2008 Split Total	15,309	3,124	33,504	13,892	5,611	22,337
2008 Whole Total	16,664	2,181	39,014	13,583	4,193	23,006
2007 RISA-East	8,997	3,872	18,356	3,408	2,854	4,010
2007 RISA-West	131	51	243	1,579	238	3,622
2007 Split Total	9,127	3,923	18,599	4,987	3,092	7,632
2007 Whole Total	9,240	4,641	14,732	8,032	4,532	13,278
2006 RISA-East	9,972	854	18,668	456	88	825
2006 RISA-West	47	21	74	2,238	69	4,406
2006 Split Total	10,019	891	19,151	2,702	159	5,246
2006 Whole Total	13,259	1,289	26,826	7,997	305	15,691

Table 4: Female spawning stock biomass estimates for both *Pandalus borealis* and *P. montagui* for the two subareas of RISA as well as the total for the two subareas. The row Whole Total is the biomass based on the original RISA stratification and is included for comparison.

	Female Spawning Stock Biomass					
	Pandalus borealis			*Pandalus montagui*		
Area	Area Wt (t)	LCL	UCL	Area Wt (t)	LCL	UCL
2008 RISA-East	6,722	1,041	14,940	6,859	1,874	11,857
2008 RISA-West	2,567	1,177	4,007	3,956	1,926	6,060
2008 Split Total	9,289	2,217	18,948	10,815	3,800	17,917
2008 Whole Total	10,047	1,488	22,544	10,689	2,794	18,661
2007 RISA-East	5,008	2,822	9,229	723	500	960
2007 RISA-West	70	20	140	1,248	129	2,948
2007 Split Total	5,152	2,842	9,368	1,971	629	3,908
2007 Whole Total	4,957	1,253	9,320	3,507	894	7,626
2006 RISA-East	6,593	481	12,701	0	0	0
2006 RISA-West	17	6	27	2,133	39	4,227
2006 Split Total	6,610	487	12,728	2,133	39	4,227
2006 Whole Total	9,076	729	18,119	7,020	86	13,956

Table 5: Fishable biomass for RISA-East, SFA2EX and SFA2 for *Pandalus borealis* and *P. montagui* for the surveys years 2006-2008. **2008*** survey in RISA-East was sampled with the modified Campelen, while in SFA2EX the standard Campelen was used. In 2006 and 2007 both areas were sampled with the standard Campelen trawl. LCL and UCL are lower and upper 95% confidence limits.

	Fishable Biomass for RISA-East					
	Pandalus borealis			*Pandalus montagui*		
Year	RISA-E Wt (t)	LCL	UCL	RISA-E Wt (t)	LCL	UCL
2008*	11,300	1,477	27,115	8,393	3,015	13,936
2007	8,997	3,872	18,356	3,408	2,854	4,010
2006	9,972	870	19,078	465	90	840

	Fishable Biomass for SFA2 Exploratory					
	Pandalus borealis			*Pandalus montagui*		
Year	SFA2EX Wt (t)	LCL	UCL	SFA2EX Wt (t)	LCL	UCL
2008	36,341	13,507	67,564	904	3	2,685
2007	34,295	11,046	64,716	12	0	37
2006	22,883	8,325	42,464	1.4	0.7	2.5

	Fishable Biomass for SFA2 Whole					
	Pandalus borealis			*Pandalus montagui*		
Year	Total Wt (t)	LCL	UCL	Total Wt (t)	LCL	UCL
2008*	47,641	14,984	94,679	9,297	3,018	16,621
2007	43,292	14,918	83,072	3,421	2,854	4,047
2006	32,855	9,195	61,542	467	91	843

Table 6: Female spawning stock biomass for RISA-East, SFA2EX and SFA2 for *Pandalus borealis* and *P. montagui* for the surveys years 2006-2008. **2008*** survey in RISA-East was sampled with the modified Campelen, while in SFA2EX the standard Campelen was used. In 2006 and 2007 both areas were sampled with the standard Campelen trawl. LCL and UCL are lower and upper 95% confidence limits.

	Female Spawning Stock Biomass for RISA-East					
	Pandalus borealis			*Pandalus montagui*		
Year	RISA-E Wt (t)	LCL	UCL	RISA-E Wt (t)	LCL	UCL
2008*	6,722	1,041	14,940	6,859	1,874	11,857
2007	5,088	2,822	9,229	723	500	960
2006	6,593	481	12,701	0.2	0.0	0.3

	Female Spawning Stock Biomass for SFA2 Exploratory					
	Pandalus borealis			*Pandalus montagui*		
Year	SFA2EX Wt (t)	LCL	UCL	SFA2EX Wt (t)	LCL	UCL
2008	18,762	7,878	32,676	95	0	284
2007	22,540	7,035	43,310	0	0	0
2006	10,195	4,348	17,803	1.4	0.7	2.5

	Female Spawning Stock Biomass - SFA2 Totals					
	Pandalus borealis			*Pandalus montagui*		
Year	Total Wt (t)	LCL	UCL	Total Wt (t)	LCL	UCL
2008*	25,484	8,918	47,616	6,955	1,874	12,141
2007	27,628	9,858	52,539	723	500	960
2006	16,788	4,829	30,504	1.6	0.7	2.9

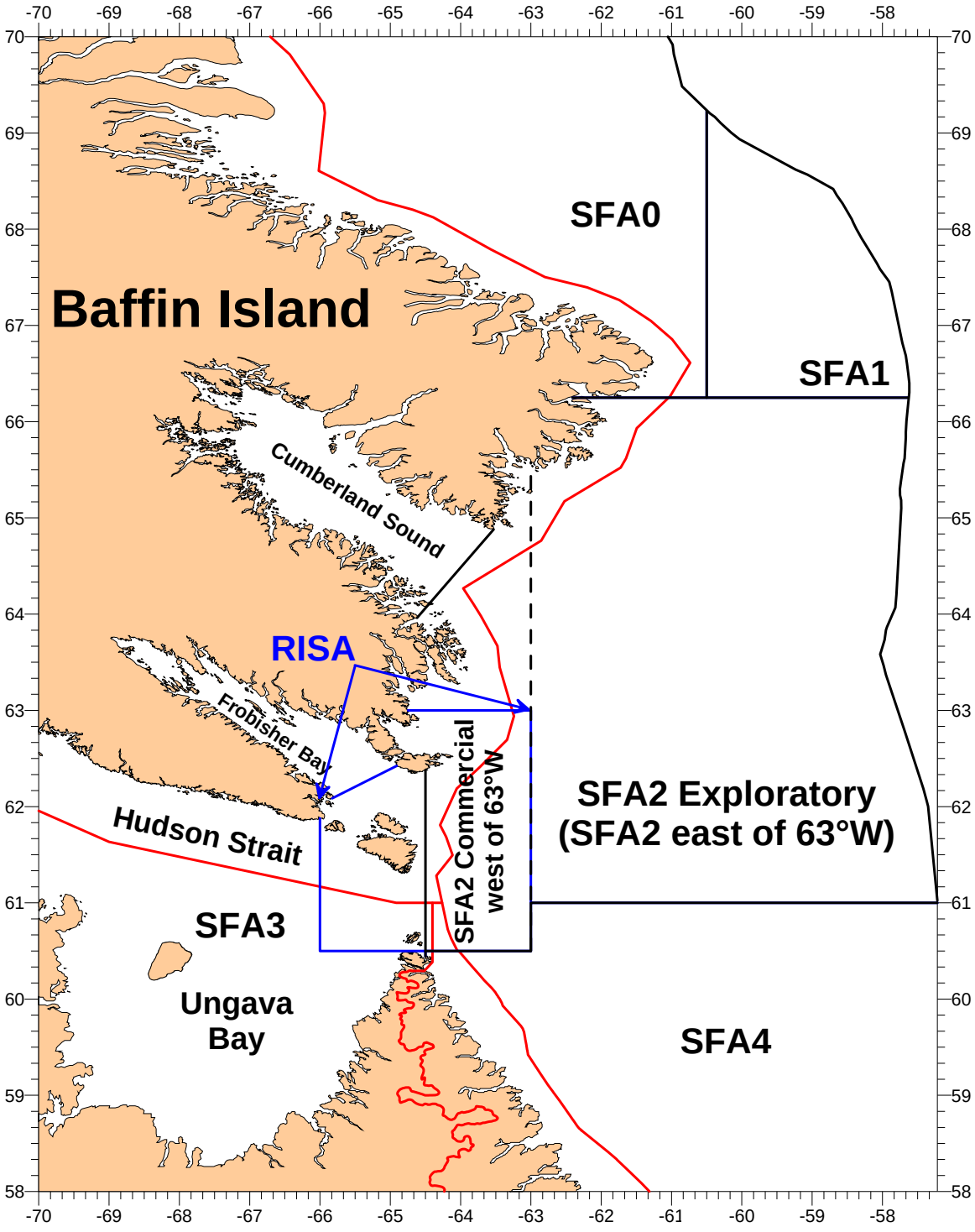

Figure 1: Large scale area map showing the Resolution Island Study Area, SFA2 Commercial box, SFA2 Exploratory and other SFAs in the north. Land claim borders are represented by red lines.

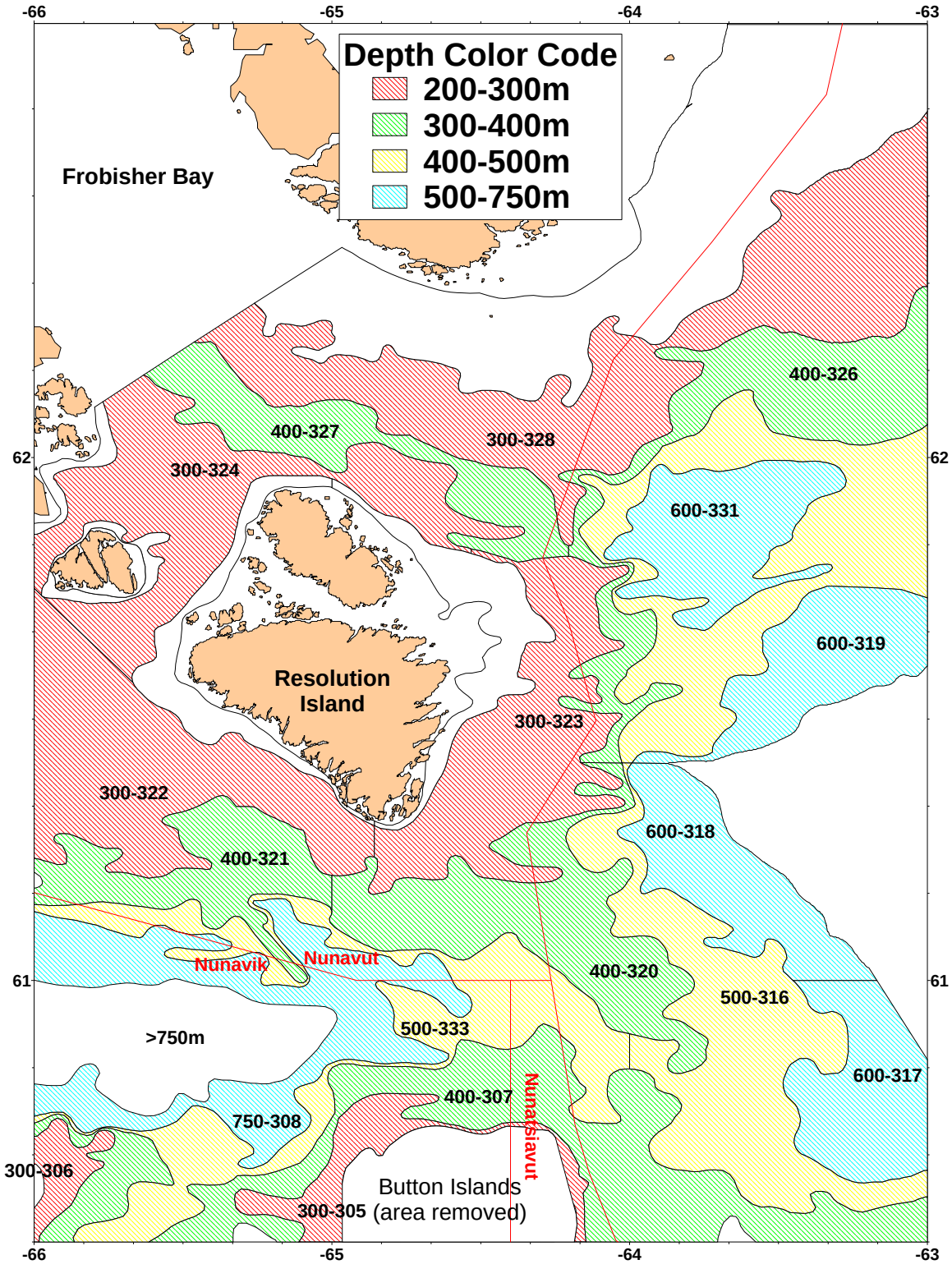

Figure 2: Original stratification map of the Resolution Island Study Area used for proportional random sample set allocation for surveys conducted in 2006-2008.

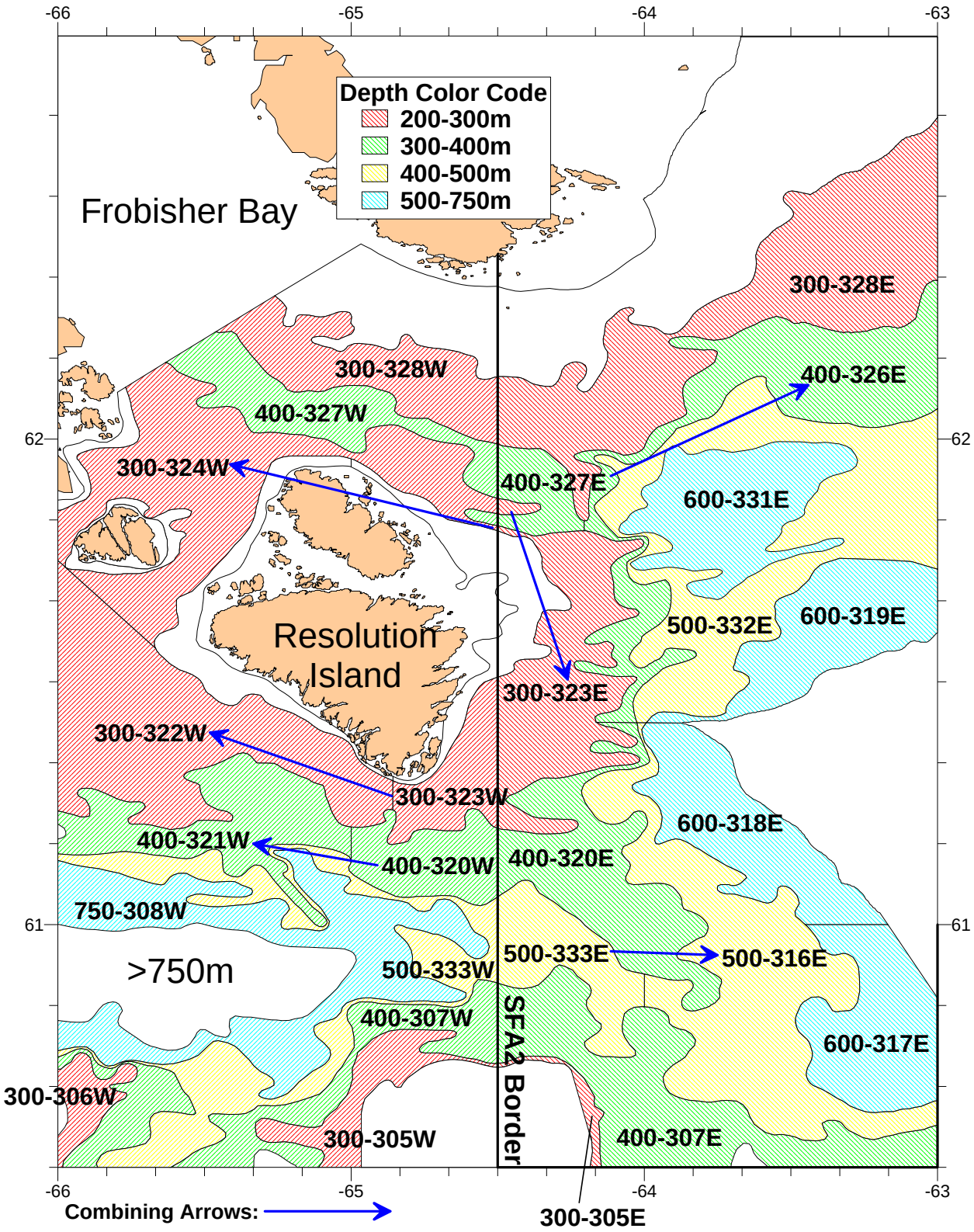

Figure 3: Split strata combining map. Straddling strata were split along the SFA2 border. Adjacent strata on each side in the same depth range were combined where possible. Arrows point to the final stratum name.

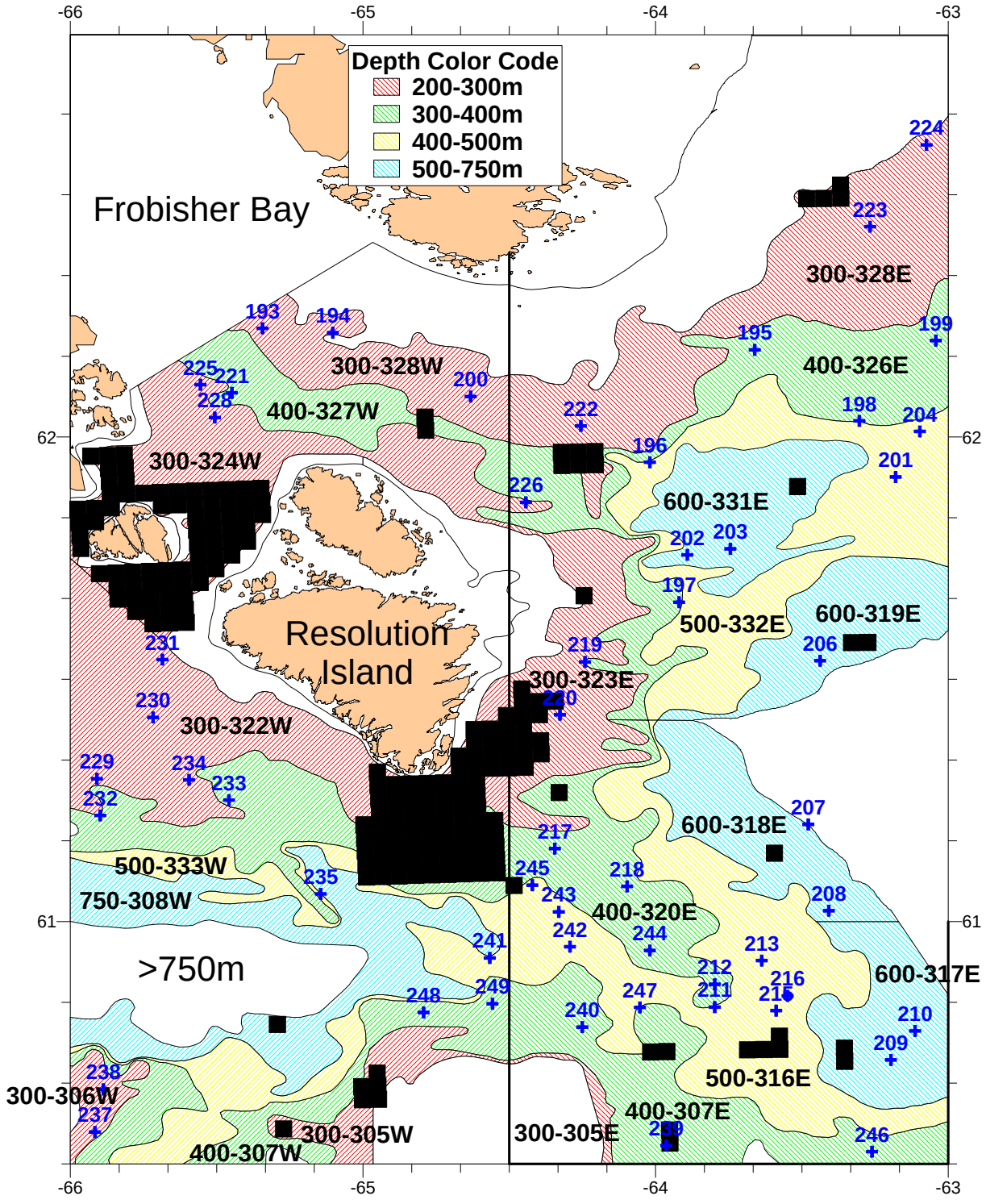

Figure 4: Successful set locations taken with the modified Campelen 1800 trawl in the 2008 survey of RISA. Note: black boxes are areas of untrawlable bottom and sets were not allocated to these areas in 2008. Black boxes are 3 km by 3 km and the size on the map is approximate.

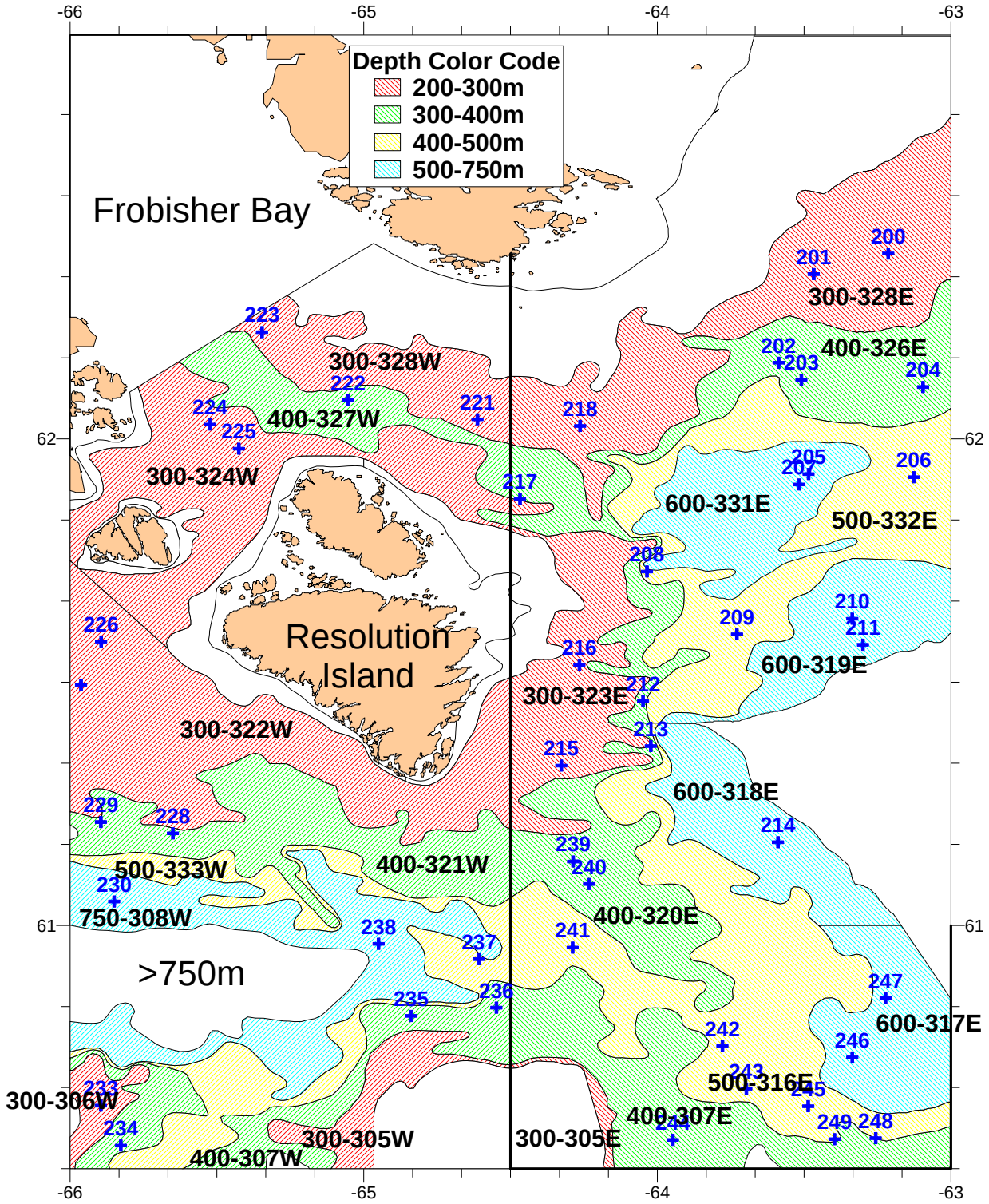

Figure 5: Successful set locations taken with the standard Campelen 1800 trawl in the 2007 survey of RISA.

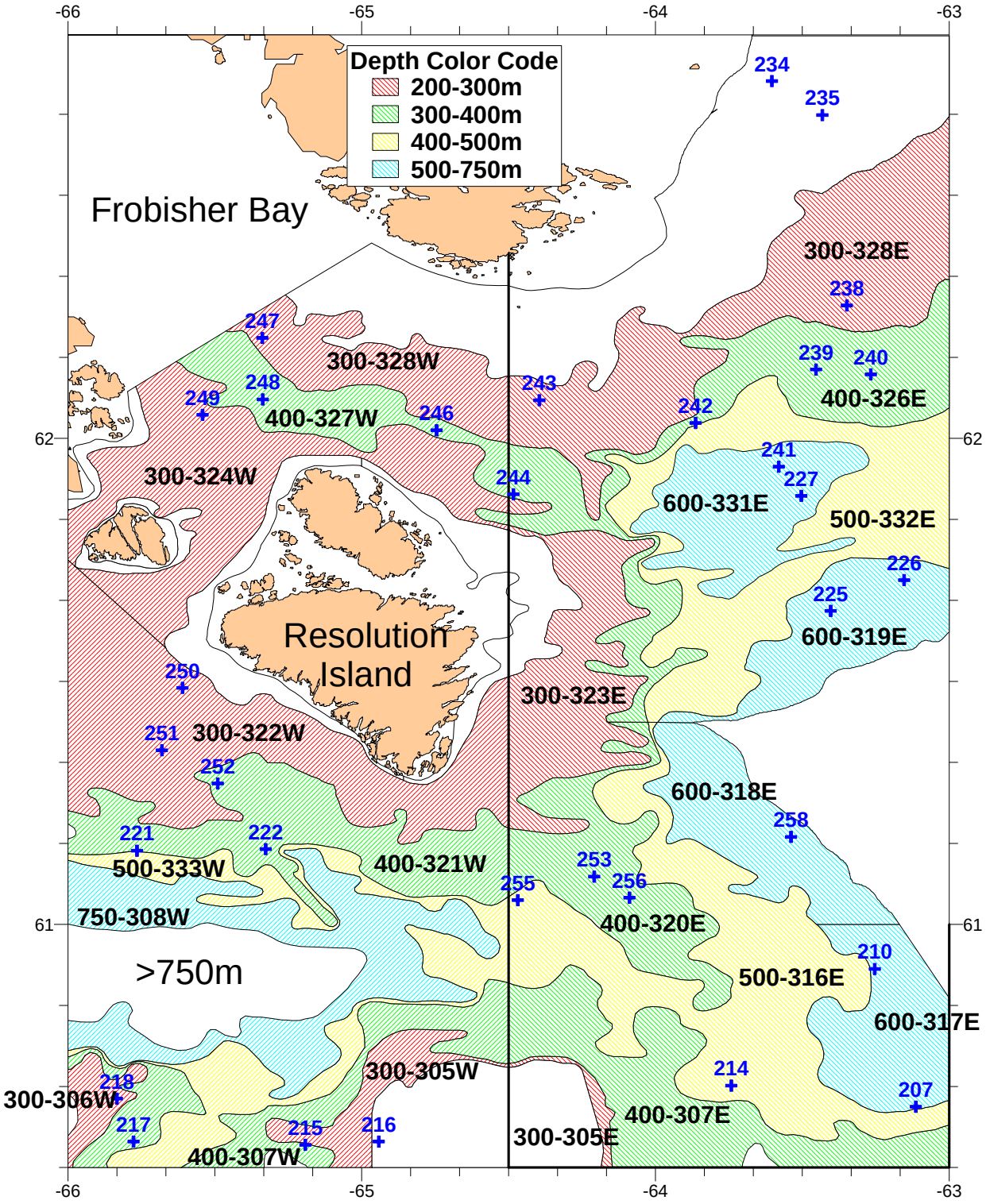

Figure 6: Successful set locations taken with the standard Campelen 1800 trawl in the 2006 survey of RISA.

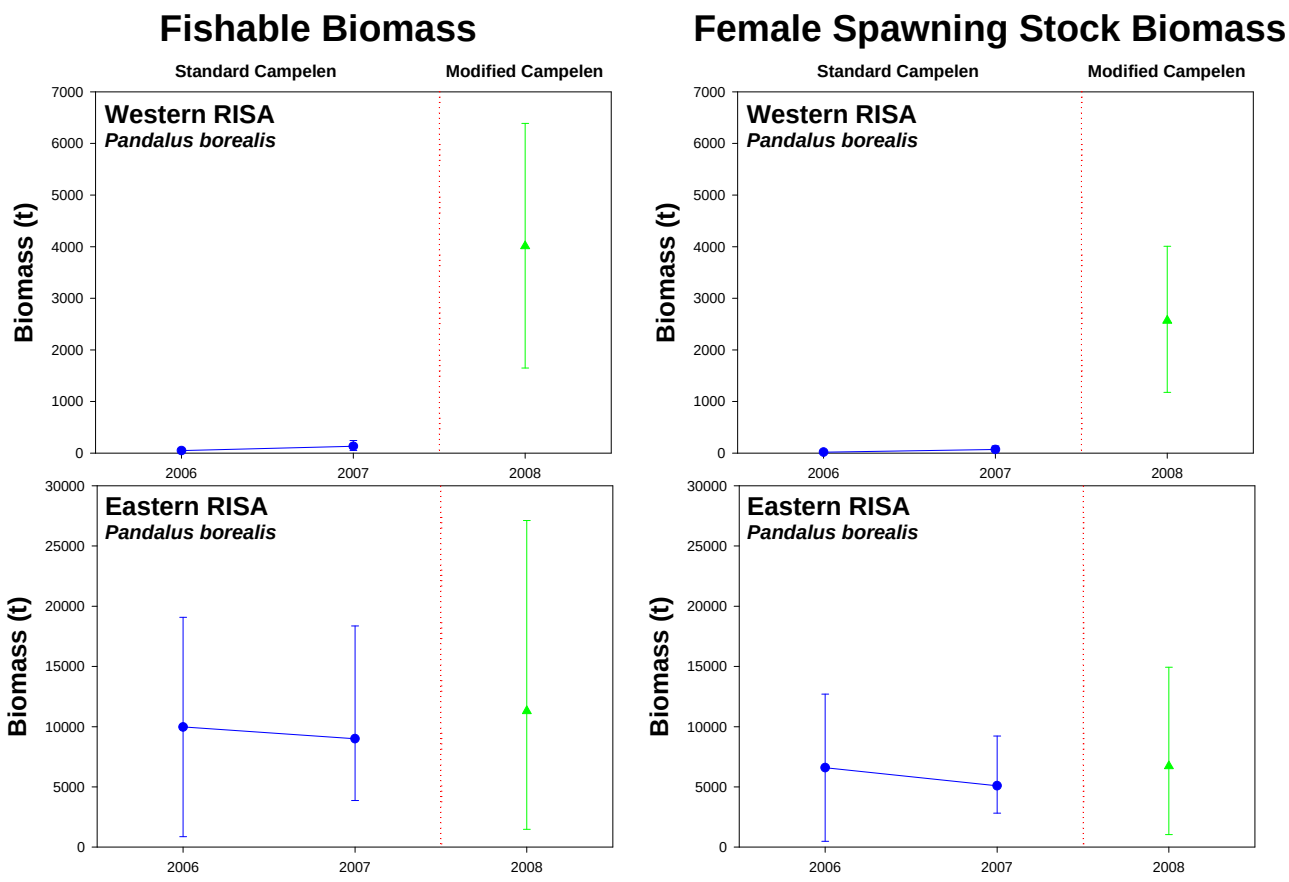

Figure 7: Fishable and female spawning stock biomass for *Pandalus borealis* in the western and eastern portions of RISA over the three survey years. The red vertical dotted line marks the change over to the modified Campelen trawl. Error bars are boot-strapped 95% confidence intervals.

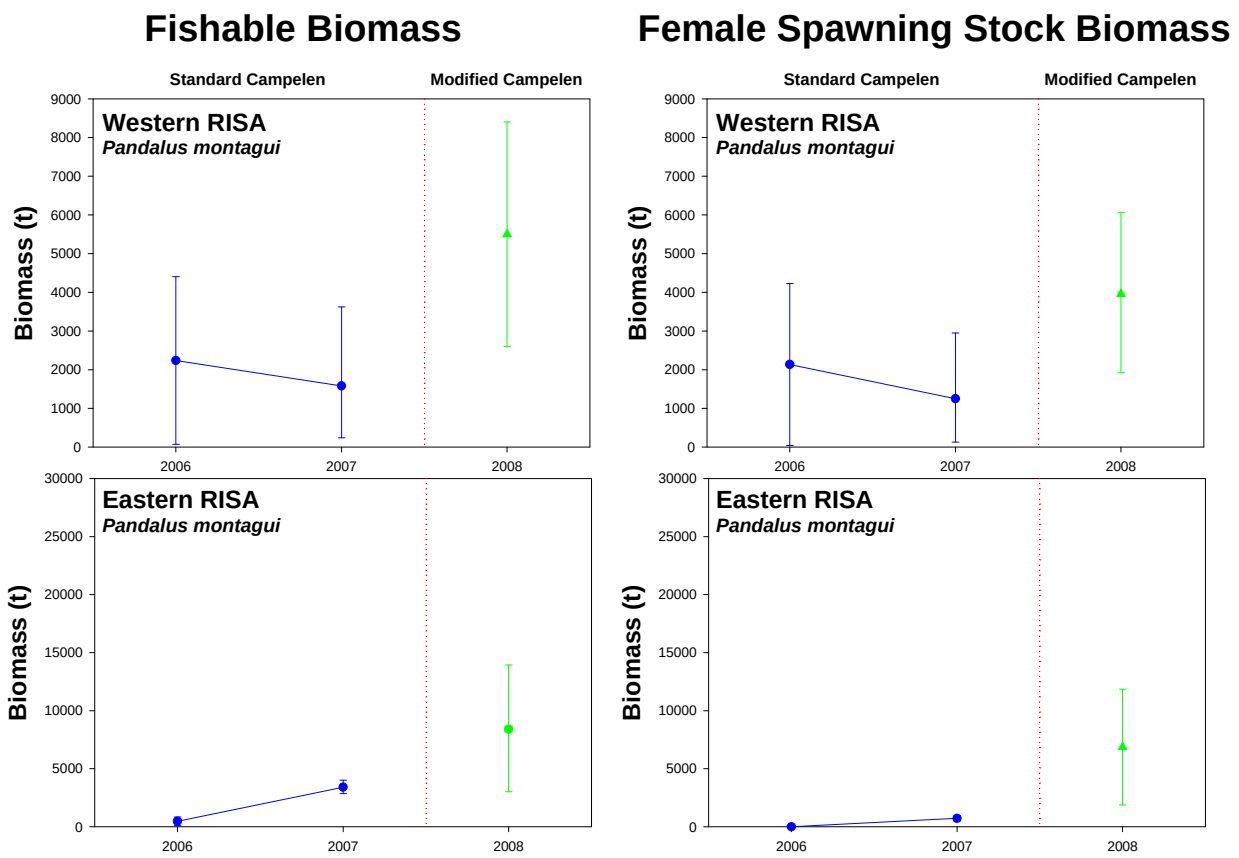

Figure 8: Fishable and female spawning stock biomass for *Pandalus montagui* in the western and eastern portions of RISA over the three survey years. The red vertical dotted line marks the change over to the modified Campelen trawl. Error bars are boot-strapped 95% confidence intervals.

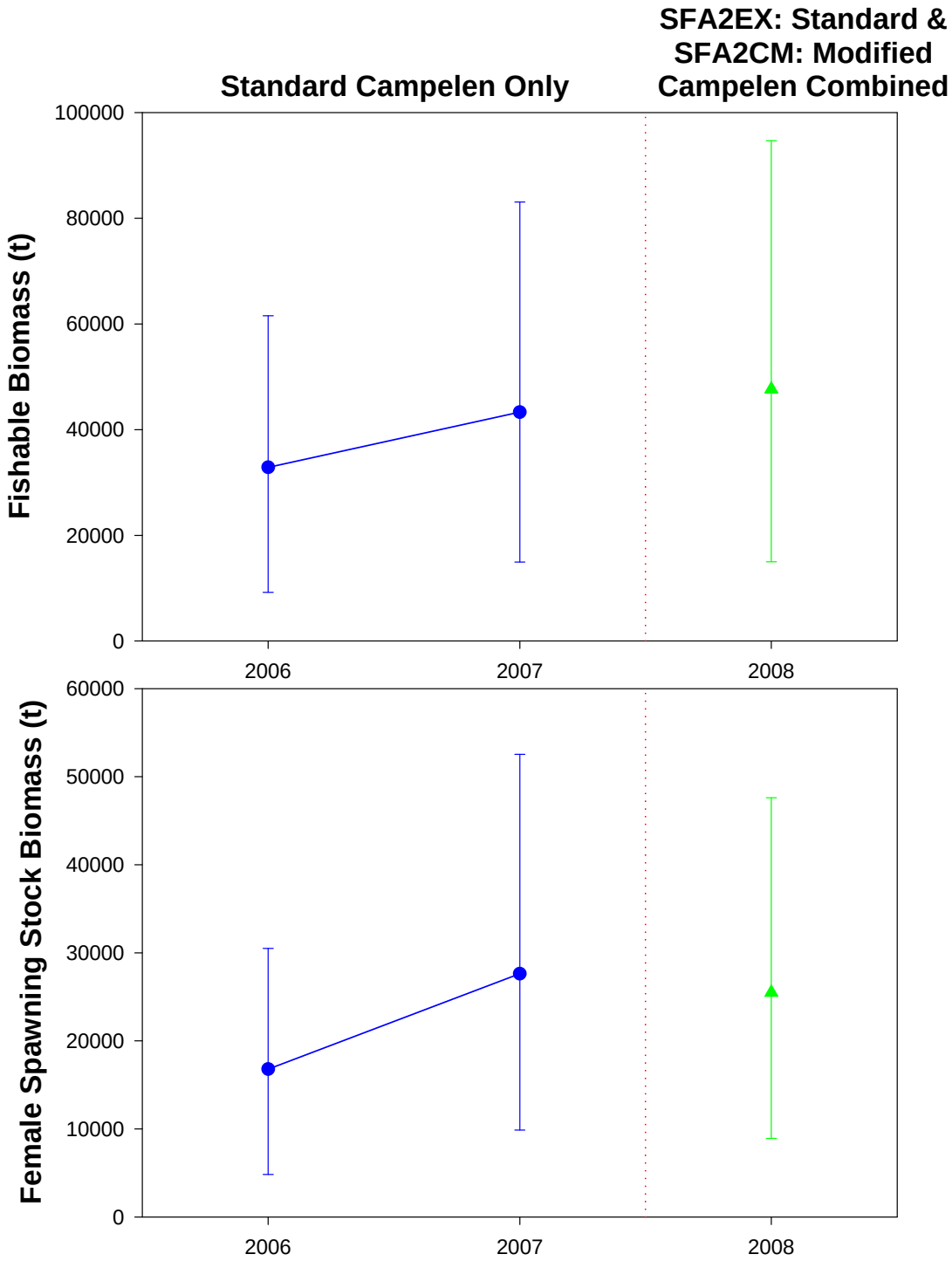

Figure 9: Fishable and female spawning stock biomass for *Pandalus borealis* for SFA2 over the surveys years 2006-2008. Totals are produced by adding the biomass estimate from SFA2CM and SFA2EX. For 2006 and 2007, both study areas were sampled with the standard Campelen trawl. In 2008, SFA2EX was sampled with the standard Campelen but RISA was sampled with the modified Campelen trawl. The red dotted vertical line indicates this break in the time series. Error bars are boot-strapped 95% confidence intervals.

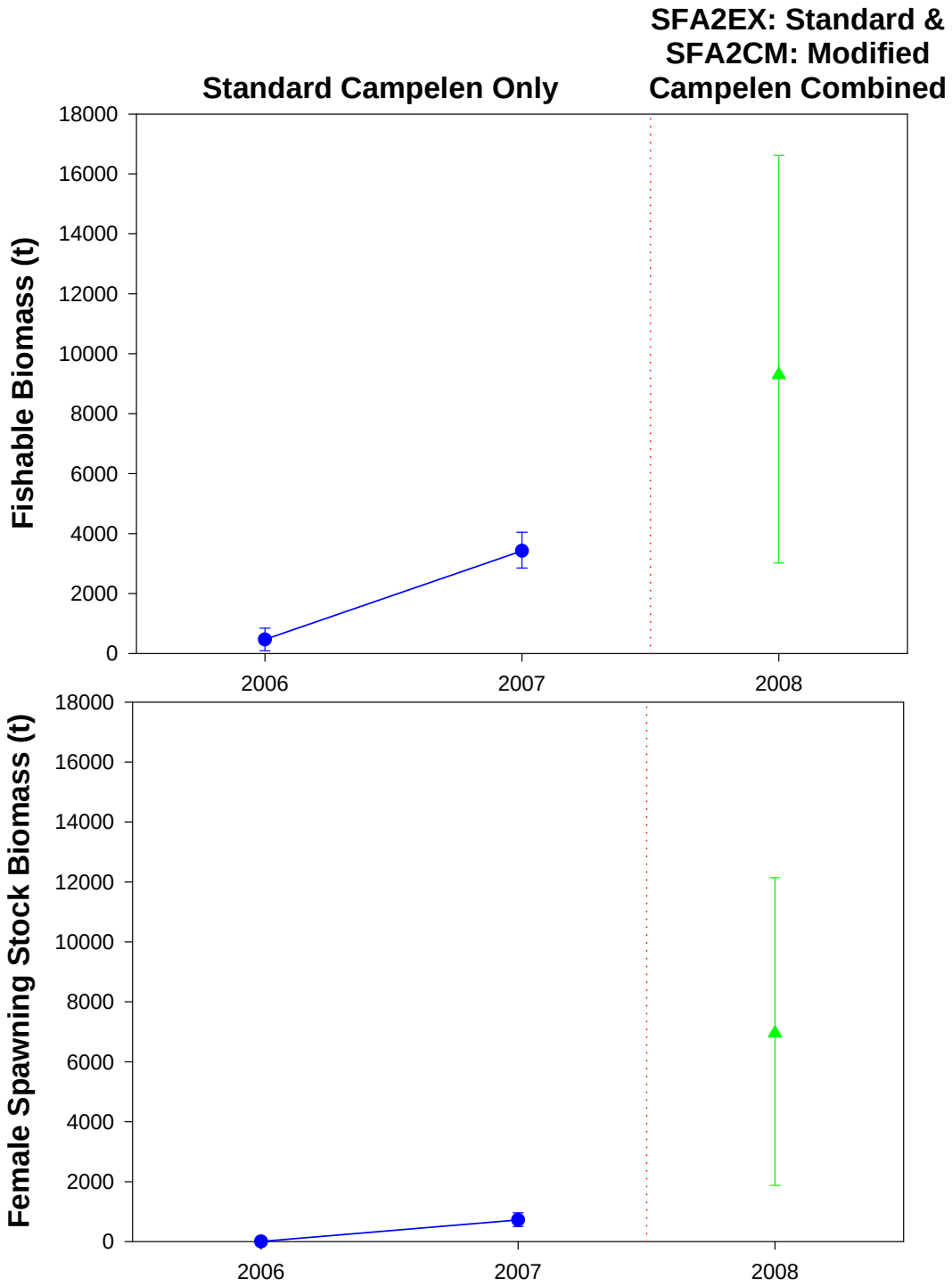

Figure 10: Fishable and female spawning stock biomass for *Pandalus montagui* for SFA2 over the surveys years 2006-2008. Totals produced by adding the biomass estimate from SFA2CM and SFA2EX. For 2006 and 2007, both study areas were sampled with the standard Campelen trawl. In 2008, SFA2EX was sampled with the standard Campelen but RISA was sampled with the modified Campelen trawl. The red dotted vertical line indicates this break in the time series. Error bars are boot-strapped 95% confidence intervals.

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