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Divisions 3LNO Northern shrimp (*Pandalus borealis*) – Interim Monitoring Update

By

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Abstract

This document updates some of the indices for northern shrimp (*Pandalus borealis*) harvested within NAFO Divisions 3LNO. A full assessment for this resource was completed, within Scientific Council during autumn 2009, and management advice was provided for the years 2010 and 2011. The catch table (to September 2010) and biomass indices (autumn 1996-spring 2010) are updated within this report. Preliminary data indicate that 27 598 t of shrimp were taken against an annual TAC of 30 000 t in 2009 while 12 799 t were taken in 2010 against an annual TAC of 30 000 t. It is anticipated that the 2010 TAC will not be taken.

The autumn 2009 3LNO biomass index was estimated to be 118,400 t, a drop of 57% since 2007 when the autumn biomass index was 275,700 t. The spring biomass index decreased by 61% from 288,600 t in 2007 to 112,500 t in 2009 but has since increased by 16 % to 130,700 t in 2010.

The autumn 2009 3LNO female spawning stock biomass (SSB) index was estimated to be 47,400 t. a drop of 63% since 2007 when the autumn SSB index was 128,000 t. The spring SSB index decreased by 67% from 176,700 t in 2007 to 59,000 t in 2009, but has since increased by 12% to 65,800 t in 2010.

Similarly, the autumn 2009 3LNO fishable biomass index was estimated to be 94,400 t in 2009, a drop of 60% from 238,100 t in 2007. The spring fishable biomass index decreased by 62% from 263,200 t in 2007 to 99,900 t in 2009, but has since increased by 13% to 112,600 t in 2010.

In 2010, Fisheries Commission requested that Scientific Council to provide information on the effect of various catch levels (NAFO, 2010). Given the recent drop in spring biomass, it was felt prudent to recalculate the TAC options. The revised values and exploitation rate indices based on various TACs are presented within this document.

Fishery and Management

TAC Determination

Prior to 2004, TACs were set at 15% of the average lower confidence interval of the survey biomass indices for the most recent four consecutive surveys. However, during 2004, Scientific Council (SC) felt it was necessary to base advice upon a new methodology due to the highly variable nature of the spring surveys. The TAC within an adjacent Canadian stock had been 12% of the fishable biomass since 1997. Applying this percentage to the inverse variance weighted average fishable biomass from the autumn 2002-spring 2004 surveys resulted in a TAC of 22 000 t. Had this new method been used in 2003, it is likely that the advised TAC for 2005 would have been around 22 000 t instead of the 13 000 t actually advised. Scientific Council noted that the TAC recommendation for this stock has always included advice that "the development of any fishery in the Div. 3L area take place in a gradual manner with conservative catch limits imposed and maintained for a number of years in order to monitor stock response." The initial TAC of 6 000 t was in place for 3 years (1999-2001), however the TAC of 13 000 t had been in place since the beginning of 2003. A two year period was insufficient to determine the impact of a 13 000 t catch

level upon the stock; therefore SC recommended that the 13 000 TAC be maintained through 2005. Scientific Council recommended that the TAC for shrimp in Div. 3LNO in 2006 should not exceed 22 000 t.

In 2008, Fishery Commission asked Scientific Council to provide a range of options, at various levels of exploitation. The TAC for 2009 of 30 000 t translated into an exploitation rate of about 14.8%, based on inverse variance weighted average fishable biomass index in 2006-2008 surveys of 202,000 tons. SC reiterated its recommendation that the fishery be restricted to Div. 3L and that the use of a sorting grate with a maximum bar spacing of 22 mm be mandatory for all vessels in the fishery (NAFO, 2008). The 2009 TAC of 30 000 t was maintained through 2010.

Catch trends

Catches increased dramatically since 1999, with the beginning of a regulated fishery. Table 1 and the following discussion provide the available numbers to date. Over the period 2000-2009, catches increased from 4 711 to 27 598 t. By September of 2010, 12 598 t of shrimp had been taken, down from 16 648 t at the same time in the previous year. It is anticipated that the 2010 quota of 30 000 t will not be taken. As per NAFO agreements, Canadian vessels took most of the catch during each year. Canadian catches increased from 4 050 t in 2000 to 21 187 t in 2008 but slightly decreased to 20 494 t in 2009. By September 2010, Canadian vessels took 9 559 t of shrimp and it is anticipated that the 24 990 t Canadian quota will not be taken by December 2010. Catches by other contracting parties increased from 661 t in 2000 to 7 703 t in 2006 and ranged between 5 500 t and 7 100 t until 2009. Preliminary data indicate that non Canadian vessels took 3 240 t of northern shrimp by September 2010 while they took 3 710 t by the same period in the previous year. It is anticipated that the 5 010 t quota for non Canadian vessels will be taken by December 2010. Table 1 provides a breakdown of catches by contracting party and year since 2000, while figure 1 indicates catches and TAC since 1993.

Canadian Multi-species Bottom Trawl Research Survey Trends

Spring and autumn multi-species research surveys have been conducted onboard the Canadian Coast Guard vessels *Wilfred Templeman*, *Teleost* and *Alfred Needler* since 1995. Shrimp data have been available from autumn surveys since 1996 while shrimp data have been available from spring surveys since 1999. Fishing sets of 15 minute duration, with a tow speed of 3 knots, were randomly allocated to strata covering the Grand Banks and slope waters to a depth of 1 462 m in the autumn and 731 m in the spring, with the number of sets in a stratum proportional to its size (Fig. 2). All vessels used a Campelen 1800 shrimp trawl with a codend mesh size of 40 mm and a 12.7 mm liner. SCANMAR sensors were employed to monitor net geometry. Details of the survey design and fishing protocols are outlined in (Brodie 1996; Brodie and Stansbury 2007; McCallum and Walsh 1996).

Prior to autumn 2003, shrimp were frozen and returned to the Northwest Atlantic Fisheries Centre where species identifications were made, and number and weight per set were calculated. Beginning with the autumn 2003 survey, most of the shrimp samples have been processed at sea. Samples that could not be processed at sea were frozen and processed in the Northwest Atlantic Fisheries Centre upon return. Abundance and biomass indices were estimated *via* OGive MAPping calculations (Evans *et al.,* 2000). We refer to Orr *et al*. (2007) to provide the full comparison of Ogmap and areal expansion indices as presented during the October 2007 NAFO-ICES Pandalus Assessment Group (NIPAG) meeting.

It must be noted that deepwater strata (deeper than 731 m) within Divisions 3LNO as well as several shallow water strata within Division 3L were not surveyed during autumn 2004 (Brodie, 2005; Healey and Dwyer, 2006). Strata that were missed, in Division 3L, (autumn 2004) are highlighted in figure 3; however, all NAFO Regulatory Area (NRA) strata containing significant quantities of northern shrimp have been surveyed consistently throughout the time series. Historically very few northern shrimp have been taken from the deepwater strata; therefore, the impact of not sampling the deepwater was felt to be negligible. However, analyses of the autumn survey data indicate that the shallow (93-549 m) 3L strata missed in 2004 are important in determining the biomass indices. Typically these strata account for 25-61% of the 3L biomass (Orr *et al.* 2007). Figure 4 confirms the importance of these strata and that catches, within these strata, vary annually. Therefore, it was not appropriate to use a multiplicative model to estimate 3L biomass and abundance indices from the autumn 2004 survey.

All important shrimp strata were surveyed in autumn 2009. The autumn 2009 biomass estimate for NAFO Divisions 3LNO was 118,400 t (95% confidence range = 79,480 – 149,200 t) a drop of 57% since 2007 when the biomass was 275,700 t (95% confidence range = 214,600 – 349,800 t) (Table 2; Fig. 5).

Due to operational difficulties it was not possible to survey all of the strata within NAFO Divisions 3NO during spring 2006. Strata 373 and 383 as well as most strata deeper than 92 m were not surveyed (Fig. 2). Analyses from the spring 1999 - 2007 surveys indicated that greater than 96% and 50% of the 3N and 3O biomass respectively may be attributed to the strata that were missed (Orr *et al.* 2007). Therefore biomass and abundance indices were not determined for NAFO Divisions 3NO during spring 2006. Historically, at least 95.9% of the spring 3LNO shrimp biomass has been found within Division 3L (Table 4); therefore, the spring 2006 indices were for NAFO Divisions 3L only. All 3LNO strata were surveyed during spring 2010. The spring 2010 survey biomass index was 130,700 t (95% confidence bounds = 76,040 – 182,800 t), a drop of approximately 54.7% since 2007 when the biomass was 288,600 t (95% confidence bounds = 190,200 – 379,200 t) (Table 2; Fig 7).

Over 92.7% of the total 3LNO biomass, from either spring or autumn surveys, was found within Division 3L, mostly within depths from 185 to 550 m. Over the study period, the area outside 200 Nmi accounted for between 11.2 and 32.6% of the estimated total 3LNO biomass (Tables 3 and 4; Figs. 4 and 6; Orr *et al.* 2007). During the autumn, the percent biomass within the NRA ranged between 12.0 and 21.0%. Three year running averages were estimated in order to smooth the peaks and troughs within the data. They indicate that 12.6 – 20.1% of the total 3LNO autumn biomass was within the NRA (Table 3). Over the period 1996 – 2008 the overall average autumn percent biomass within the NRA was 16.8%. During the spring, the percent biomass within the NRA ranged between 11.2 and 32.6% (three year running average ranged between 19.2 and 25.0%) (Table 4). Over the period 1999 – 2009 the average spring percent biomass with the NRA was 23.1%. It must be noted that variances around the spring indices are greater than around autumn indices (Table 2; Figs. 4-7).

In all surveys, Division 3N accounted for 0.2-8.1% of the total 3LNO biomass (Tables 3 and 4). Between 33.3 and 83.3% of the 3N biomass was found outside the 200 Nmi limit. Division 3O accounted for less than 1% of the 3LNO biomass. A negligible amount of the Division 3O biomass was found outside the 200 Nmi limit.

The autumn 2009 3LNO female spawning stock biomass (SSB) index was estimated to be 47,400 t. a drop of 63% since 2007 when the autumn SSB index was 128,000 t. The spring SSB index decreased by 67% from 176,700 t in 2007 to 59,000 t in 2008, but has since increased by 12% to 65,800 t in 2010 (Table 5; Fig. 8).

The autumn 2009 3LNO fishable biomass index was estimated to be 94,400 t in 2009, a drop of 60% from 238,100 t in 2007. The spring fishable biomass index decreased by 62% from 263,200 t in 2007 to 99,900 t in 2009, but has since increased by 13% to 112,600 t in 2010 (Table 6; Fig. 9).

The inverse variance weighted average fishable biomass, determined over the period autumn 2008 – spring 2010, was 120,180 t. Exploitation rates at various TAC options are provided in table 7.

Conclusions

Preliminary data indicate that 12 799 t of shrimp had been taken in the 3L shrimp fishery by September 2010; however, it is doubtful that the entire 30 000 t quota will be taken by the end of December 2010.

The autumn 2009 3LNO biomass index was estimated to be 118,400 t, a drop of 57% since 2007 when the autumn biomass index was 275,700 t. The spring biomass index decreased by 61% from 288,600 t in 2007 to 112,500 t in 2008 but has since increased by 16 % to 130,700 t in 2010.

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It is important to note that confidence intervals around the spring indices are generally broader than they are for the autumn indices therefore, the spring indices are thought to be less precise.

Acknowledgements

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Table 1. Annual nominal catches (t) by country of northern shrimp (*Pandalus borealis*) caught in NAFO Div. 3L between 2000 and September 2010.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Canada	4,050[2]	4,984[2]	5,417[2]	10,701[2]	10,560[2]	11,109[2]	18,128[2]	18,316[2]	21,187[2]	20,494[2]	9,559[2]
Cuba		46[1]	70[1]	81[1]	145[3]	136[1]	239[1]	240[1]	207[3]	334[3]	
EU/Estonia	64[1]	2,264[4]	450[5]	299[6]	271[6]	569[6]	1,098[10]	1,453[10]	1,458[10]	1659[10]	
European Union											689[3]
Faroe Islands	42[1]	2,052[4]	620[5]	25[1]	1,050[1]	1,055[1]	1,521[1]	1,798[1]	2,273[1]	2948[3]	1459[3]
France (SPM)	67[1]	67[1]	36[1]	144[1]				245[1]	278[1]	334[1]	
Greenland	34[1]			671[1]	299[1]	311[1]	453[8]	455[8]	648[8]	488[8]	741[8]
Iceland	99[1]	55[7]	54[7]	133[7]	105[7]	140[1]	226[7]				
EU/Latvia	64[1]	67[1]	59[1]	144[1]	143[1]	144[1]	244[1]	310[1]	278[1]		
EU/Lithuania	67[1]	67[1]	67[1]	142[1]	144[1]	216[1]	486[1]	245[1]	278[1]		
Norway	77[1]	78[6]	70[6]	145[9]	165[9]	144[3]	272[9]	250[9]	345[1]	672[1]	325[3]
EU/Poland	40[1]	54[1]		145[1]	144[1]	129[1]	245[1]				
Portugal		61[5]									
Russia	67[1]	67[1]	67[1]		141[1]	146[1]	248[1]	112[1]	278[1]	335[3]	26[3]
EU/Spain	40[1]	699[4]		151[1]	140[1]	154[1]	305[6]	190[1]	183[1]		
Ukraine		57[1]		144[1]	145[1]		121[1]			334[3]	
USA		66[1]	57[1]	144[1]		136[1]	245[1]	245[1]	278[3]		
Estimated additional catch							2,000[5]				
GRAND TOTAL	4,711	10,684	6,967	13,069	13,452	14,389	25,831	23,859	27,691	27,598	12,799
TAC (tons)	6,000	6,000	6,000	13,000	13,000	13,000	22,000	22,000	25,000	30,000	30,000

Sources:

1 NAFO Statlant 21A
2 Canadian Atlantic Quota Report, or other preliminary sources
3 NAFO monthly records of provisional catches
4 Value agreed upon in Stacfis
5 Canadian surveillance reports
6 Observer datasets
7 Icelandic logbook dataset.
8 Greenlandic logbook dataset.
9 Norwegian logbook dataset.
10 Estonian logbook dataset.

Table 2. Northern shrimp biomass estimates in NAFO divisions 3LNO from annual spring and autumn Canadian multi-species bottom trawl surveys, 1996 – 2010. Offshore strata only (standard 15 min. tows). Please note that autumn 2004 indices were not determined due to missing strata. Strata deeper than 93 m were not surveyed in 3NO during spring 2006. Historically more than 97% of the shrimp have been attributed to strata within 3L therefore the spring 2006 estimates are for 3L. All indices were determined using Ogive Mapping calculations. All indices were determined using Ogive Mapping calculations.

Year	Biomass (tons)			Abundance (numbers x 10^6)			Survey
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1999	26,990	49,400	76,190	6,564	11,418	17,300	313
2000	65,710	113,300	176,700	13,150	21,357	31,590	298
2001	52,680	82,500	117,100	12,250	19,718	28,540	300
2002	87,390	133,800	204,700	20,730	31,263	47,660	304
2003	117,200	169,600	222,600	26,370	38,967	53,790	300
2004	40,960	93,500	169,100	8,172	17,999	31,890	296
2005	85,630	133,400	183,500	16,800	25,553	34,860	289
2006	107,400	177,200	246,300	21,260	34,086	46,340	195
2007	190,200	288,600	379,200	35,340	54,306	72,790	295
2008	170,800	223,200	277,200	35,150	45,997	55,980	273
2009	62,850	112,500	167,500	14,430	24,447	35,180	299
2010	76,040	130,700	182,800	16,110	26,445	36,820	288

[1] **Area compared each year = 272,766.3 sq. km.**

Spring

Year	Biomass (tons)			Abundance (numbers x 106)			Survey
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	20,150	24,700	35,010	5,342	6,580	9,390	304
1997	32,410	44,000	61,940	7,550	9,917	13,870	318
1998	48,320	60,700	76,650	11,950	14,980	19,130	347
1999	43,160	54,900	72,400	10,620	12,997	16,520	313
2000	83,990	107,000	139,200	20,890	27,901	35,830	337
2001	155,300	215,500	259,600	36,890	51,732	62,040	362
2002	135,500	191,700	239,500	31,110	44,475	54,760	365
2003	144,000	191,000	243,400	30,470	39,669	49,590	316
2004		???			???		
2005	177,500	222,600	264,600	35,490	45,083	53,730	333
2006	172,900	215,400	252,000	36,450	47,034	55,700	312
2007	214,600	275,700	349,800	43,620	56,852	71,460	361
2008	195,800	249,300	301,800	40,740	53,252	65,020	256
2009	79,480	118,400	149,200	19,580	29,488	35,940	315

Area compared each year = 272,766.3 sq. km.

Autumn

Table 3. NAFO Divisions 3LNO *Pandalus borealis* biomass estimates for entire divisions and outside the 200 Nmi limit. Shrimp were collected during the 1996 – 2009 **autumn** Canadian multi-species surveys using a Campelen 1800 shrimp trawl (standard 15 min tows). All indices were estimated using Ogmap calculations.

			Entire Division		Outside 200 Nmi limit			
Season	Year	Division	Biomass estimate (t)	Percent by division	Biomass estimate (t)	Percent biomass by division	percent biomass in NRA	3 year running average percent biomass in NRA
Autumn	1996	3L	22,900	92.71	4,000	85.11	17.47	17.47
Autumn	1997	3L	43,400	98.64	5,500	91.67	12.67	15.07
Autumn	1998	3L	56,000	92.26	8,900	81.65	15.89	15.34
Autumn	1999	3L	54,500	99.27	8,000	96.39	14.68	14.41
Autumn	2000	3L	105,800	98.88	22,100	98.22	20.89	17.15
Autumn	2001	3L	213,700	99.21	40,800	97.14	19.09	18.22
Autumn	2002	3L	187,800	97.97	35,200	92.39	18.74	19.57
Autumn	2003	3L	185,200	97.01	35,600	91.75	19.22	19.02
Autumn	2004	3L	???	???	???	???	???	???
Autumn	2005	3L	221,200	99.37	26,200	97.40	11.84	15.53
Autumn	2006	3L	213,700	99.21	27,100	96.44	12.68	12.26
Autumn	2007	3L	271,500	98.48	49,700	98.42	18.31	14.28
Autumn	2008	3L	246,200	98.76	32,900	97.92	13.36	14.78
Autumn	2009	3L	116,800	98.65	18,100	97.84	15.50	15.72
Autumn	1996	3N	2,000	8.10	700	14.89	35.00	35.00
Autumn	1997	3N	700	1.59	500	8.33	71.43	53.21
Autumn	1998	3N	4,700	7.74	2,000	18.35	42.55	49.66
Autumn	1999	3N	500	0.91	300	3.61	60.00	57.99
Autumn	2000	3N	700	0.65	400	1.78	57.14	53.23
Autumn	2001	3N	1,700	0.79	1,200	2.86	70.59	62.58
Autumn	2002	3N	4,000	2.09	2,900	7.61	72.50	66.74
Autumn	2003	3N	4,700	2.46	3,200	8.25	68.09	70.39
Autumn	2004	3N	2,600	???	2,100	???	???	???
Autumn	2005	3N	1000	0.45	700	2.60	70.00	69.04
Autumn	2006	3N	1,500	0.70	1000	3.56	66.67	68.33
Autumn	2007	3N	1,300	0.47	800	1.58	61.54	66.07
Autumn	2008	3N	1,300	0.52	700	2.08	53.85	60.68
Autumn	2009	3N	800	0.68	400	2.16	50.00	55.13
Autumn	1996	3O	0	0.00	0	0.00	0.00	0.00
Autumn	1997	3O	0	0.00	0	0.00	0.00	0.00
Autumn	1998	3O	100	0.16	0	0.00	0.00	0.00
Autumn	1999	3O	0	0.00	0	0.00	0.00	0.00
Autumn	2000	3O	0	0.00	0	0.00	0.00	0.00
Autumn	2001	3O	0	0.00	0	0.00	0.00	0.00
Autumn	2002	3O	100	0.05	0	0.00	0.00	0.00
Autumn	2003	3O	200	0.10	0	0.00	0.00	0.00
Autumn	2004	3O	200	???	0	???	???	???
Autumn	2005	3O	100	0.04	0	0.00	0.00	0.00
Autumn	2006	3O	0	0.00	0	0.00	0.00	0.00
Autumn	2007	3O	0	0.00	0	0.00	0.00	0.00
Autumn	2008	3O	0	0.00	0	0.00	0.00	0.00
Autumn	2009	3O	0	0.00	0	0.00	0.00	0.00
	all divisions							
Autumn	1996		24,700	101	4,700	100	19.03	19.03
Autumn	1997		44,000	100	6,000	100	13.64	16.33
Autumn	1998		60,700	100	10,900	100	17.96	16.87
Autumn	1999		54,900	100	8,300	100	15.12	15.57
Autumn	2000		107,000	100	22,500	100	21.03	18.03
Autumn	2001		215,400	100	42,000	100	19.50	18.55
Autumn	2002		191,700	100	38,100	100	19.87	20.13
Autumn	2003		190,900	100	38,800	100	20.32	19.90
Autumn	2004		???		???		???	???
Autumn	2005		222,600	100	26,900	100	12.08	16.20
Autumn	2006		215,400	100	28,100	100	13.05	12.56
Autumn	2007		275,700	99	50,500	100	18.32	14.48
Autumn	2008		249,300	99	33,600	100	13.48	14.95
Autumn	2009		118,400	99	18,500	100	15.63	15.81

Table 4. NAFO Divisions 3LNO *Pandalus borealis* biomass estimates for entire divisions and outside the 200 Nmi limit. Shrimp were collected during the 1999 – 2009 **spring** Canadian multi-species surveys using a Campelen 1800 shrimp trawl (standard 15 min tows). Please note that strata deeper than 93 m were not surveyed in 3NO during spring 2006. Historically more than 97% of the shrimp have been attributed to strata within 3L therefore the spring 2006 estimates are for 3L. All indices were estimated using Ogmap calculations.

			Entire Division		Outside 200 Nmi limit			
Season	Year	Division	Biomass estimate (t)	Percent by division	Biomass estimate (t)	Percent biomass by division	percent biomass in NRA	3 year running average percent biomass in NRA
Spring	1999	3L	47,500	96.15	10,200	86.44	21.47	
Spring	2000	3L	108,700	95.94	23,800	87.18	21.90	
Spring	2001	3L	82,700	100.24	11,400	99.13	13.78	19.05
Spring	2002	3L	128,100	95.74	34,300	91.47	26.78	20.82
Spring	2003	3L	165,400	97.52	29,900	86.92	18.08	19.55
Spring	2004	3L	92,000	98.40	23,700	97.13	25.76	23.54
Spring	2005	3L	133,200	99.85	14,200	94.67	10.66	18.17
Spring	2006	3L	179,400	???	43,400	???	24.19	20.20
Spring	2007	3L	282,100	97.75	78,200	97.02	27.72	20.86
Spring	2008	3L	231,700	99.70	34,300	99.13	14.80	22.24
Spring	2009	3L	110,200	97.96	36,200	98.64	32.85	25.12
Spring	2010	3L	129,800	99.31	41,800	99.52	32.20	26.62
Spring	1999	3N	2,100	4.25	1,600	13.56	76.19	
Spring	2000	3N	4,700	4.15	3,500	12.82	74.47	
Spring	2001	3N	300	0.36	100	0.87	33.33	61.33
Spring	2002	3N	5,800	4.33	3,200	8.53	55.17	54.32
Spring	2003	3N	5,400	3.18	4,500	13.08	83.33	57.28
Spring	2004	3N	1,200	1.28	700	2.87	58.33	65.61
Spring	2005	3N	1,400	1.05	800	5.33	57.14	66.27
Spring	2006	3N	???	???	???	???	???	57.74
Spring	2007	3N	3,100	1.07	2,400	2.98	77.42	67.28
Spring	2008	3N	600	0.26	300	0.87	50.00	63.71
Spring	2009	3N	700	0.62	500	1.36	71.43	66.28
Spring	2010	3N	400	0.31	200	0.48	50.00	57.14
Spring	1999	3O	100	0.20	0	0.00	0.00	
Spring	2000	3O	100	0.09	0	0.00	0.00	
Spring	2001	3O	0	0.00	0	0.00	0.00	0.00
Spring	2002	3O	100	0.07	0	0.00	0.00	0.00
Spring	2003	3O	200	0.12	0	0.00	0.00	0.00
Spring	2004	3O	200	0.21	0	0.00	0.00	0.00
Spring	2005	3O	100	0.07	0	0.00	0.00	0.00
Spring	2006	3O	1,000	???	100	???	10.00	0.00
Spring	2007	3O	0	0.00	0	0.00	0.00	0.00
Spring	2008	3O	0	0.00	0	0.00	0.00	0.00
Spring	2009	3O	0	0.00	0	0.00	0.00	0.00
Spring	2010	3O	100	0.00	0	0.00	0.00	0.00
	all divisions							
Spring	1999		49,400	100.61	11,800	100.00	23.89	
Spring	2000		113,300	100.18	27,300	100.00	24.10	
Spring	2001		82,500	100.61	11,500	100.00	13.94	20.64
Spring	2002		133,800	100.15	37,500	100.00	28.03	22.02
Spring	2003		169,600	100.83	34,400	100.00	20.28	20.75
Spring	2004		93,500	99.89	24,400	100.00	26.10	24.80
Spring	2005		133,400	100.97	15,000	100.00	11.24	19.21
Spring	2006		???	???	???	???	???	18.67
Spring	2007		288,600	98.82	80,600	100.00	27.93	19.59
Spring	2008		232,400	99.96	34,600	100.00	14.89	21.41
Spring	2009		112,500	98.58	36,700	100.00	32.62	25.15
Spring	2010		130,700	99.62	42,000	100.00	32.13	26.55

Table 5. Female spawning stock biomass (t) as determined using ogmap calculations from Canadian spring and autumn bottom trawl survey data. All indices were estimated using Ogmap calculations.

Year	Biomass (tons)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1999	11,610	20,000	29,550	1,517	2,655	3,956
2000	28,540	50,300	78,820	3,722	6,562	10,130
2001	23,130	32,500	43,870	3,231	4,648	6,361
2002	38,730	54,600	80,140	6,209	8,757	12,890
2003	58,350	74,400	101,300	9,096	12,479	16,060
2004	21,240	41,800	67,320	2,931	5,692	9,094
2005	51,000	80,800	111,800	6,679	10,745	15,090
2006	59,150	101,200	143,400	7,692	13,093	18,400
2007	110,900	176,700	241,100	14,370	22,970	31,550
2008	91,920	128,600	160,500	12,140	16,899	20,940
2009	30,300	59,000	97,490	4,391	8,408	13,600
2010	41,210	65,800	90,160	5,680	8,932	12,200

Spring

Please note that strata deeper than 93 m were not surveyed in 3NO during spring 2006. Historically more than 97% of the shrimp have been attributed to strata within 3L therefore the spring 2006 estimates are for 3L.

Year	Biomass (tons)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	4,401	5,800	10,300	519	661	1,159
1997	13,040	19,200	28,440	1,801	2,720	4,032
1998	14,670	18,200	24,190	1,762	2,134	2,844
1999	17,560	21,700	30,830	2,445	3,000	4,173
2000	24,340	32,600	46,250	3,229	4,249	5,925
2001	41,990	63,500	85,860	5,645	8,138	10,920
2002	49,550	69,500	93,800	6,802	9,595	13,030
2003	59,860	82,800	111,500	7,892	10,814	14,440
2004						
2005	69,790	94,800	121,700	8,336	11,147	14,340
2006	62,820	82,600	107,900	7,305	9,637	12,680
2007	94,070	128,000	168,500	11,890	15,781	20,650
2008	76,720	105,200	138,500	9,221	12,571	16,760
2009	32,330	47,400	66,050	4,214	6,172	8,536

Autumn

The autumn 2004 survey did not occupy important strata within the shrimp resource therefore no estimations were made for that year.

Table 6. Fishable biomass (t) indices (total weight of all males + females with carapace lengths => 17.5 mm) as determined using ogmap calculations from spring and autumn Canadian multi-species bottom trawl survey data, 1996 – 2010. Please note that strata deeper than 93 m were not surveyed in 3NO during spring 2006. Historically more than 97% of the shrimp have been attributed to strata within 3L therefore the spring 2006 estimates are for 3L. All indices were estimated using Ogmap calculations.

Year	Spring			Autumn		
	Lower 95% C.I.	Estimate (t)	Upper 95% C.I.	Lower 95% C.I.	Estimate (t)	Upper 95% C.I.
1996				12,110	14,200	22,230
1997				23,500	34,200	49,270
1998				36,080	46,900	63,770
1999	20,350	40,600	64,210	33,280	42,200	57,790
2000	41,480	80,000	131,700	62,660	79,900	106,800
2001	43,130	66,900	94,310	123,700	173,900	217,800
2002	73,100	112,900	174,800	112,300	158,800	200,100
2003	110,400	154,400	201,100	124,300	168,600	219,000
2004	34,520	82,200	151,000		???	
2005	72,630	115,800	161,700	142,700	178,700	214,500
2006	93,640	160,600	221,300	137,400	172,600	204,900
2007	169,900	263,200	350,300	182,200	238,100	304,900
2008	136,600	186,700	234,300	159,000	205,000	253,500
2009	54,760	99,900	154,000	63,310	94,400	123,600
2010	65,810	112,600	159,100			

Table 7. Inverse variance weighted average fishable biomass from the four most recent Canadian research surveys into 3LNO with exploitation rates based upon various TAC options..

Variance weighting factor = fishable biomass/(measure of variance)^2÷Σ fishable biomass/(measure of variance)^2

Survey	Fishable biomass (t)	Fishable biomass – lower 95% C.I.= measure of variance	Fishable biomass/ (measure of variance^2)	1/measure of variance^2	Variance weighting factor
Autumn 2008	205,000	46,000	9.68809E-05	4.73E-10	0.193
Spring 2009	99,900	54,140	4.90278E-05	4.91E-10	0.200
Autumn 2009	94,400	31,090	9.76631E-05	1.03E-09	0.421
Spring 2010	112,600	46,790	5.14319E-05	4.57E-10	0.186
Grand total			2.95004E-04	2.455E-09	1.00

Inverse variance weighted average fishable biomass = 2.95004E-04 / 2.455E-09
= 120,180 t

TACs options at various percent exploitation rates (catch/fishable biomass)

inverse variance averaged fishable biomass	10%	15%	20%	22.47%	24.96%
120,180	12,018	18,027	24,000	27,000	30,000

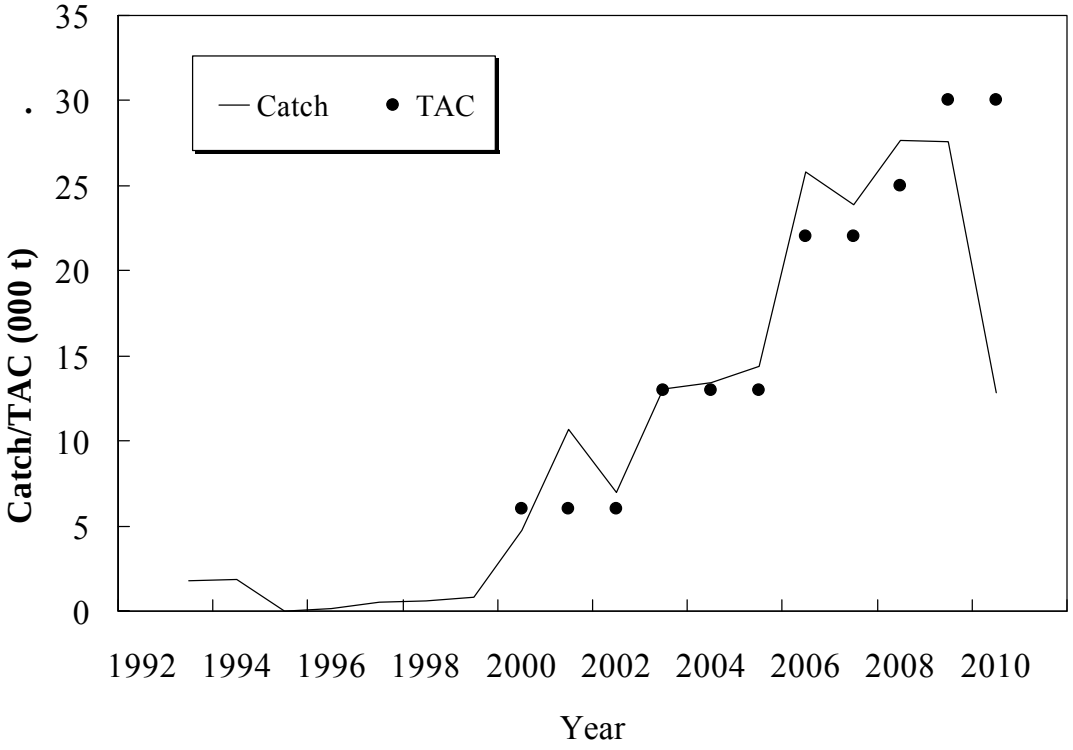


Figure 1. Trends in NAFO Divs. 3LNO Northern Shrimp (*Pandalus borealis*) catch (t) and TAC over the period 1993 – 2010.

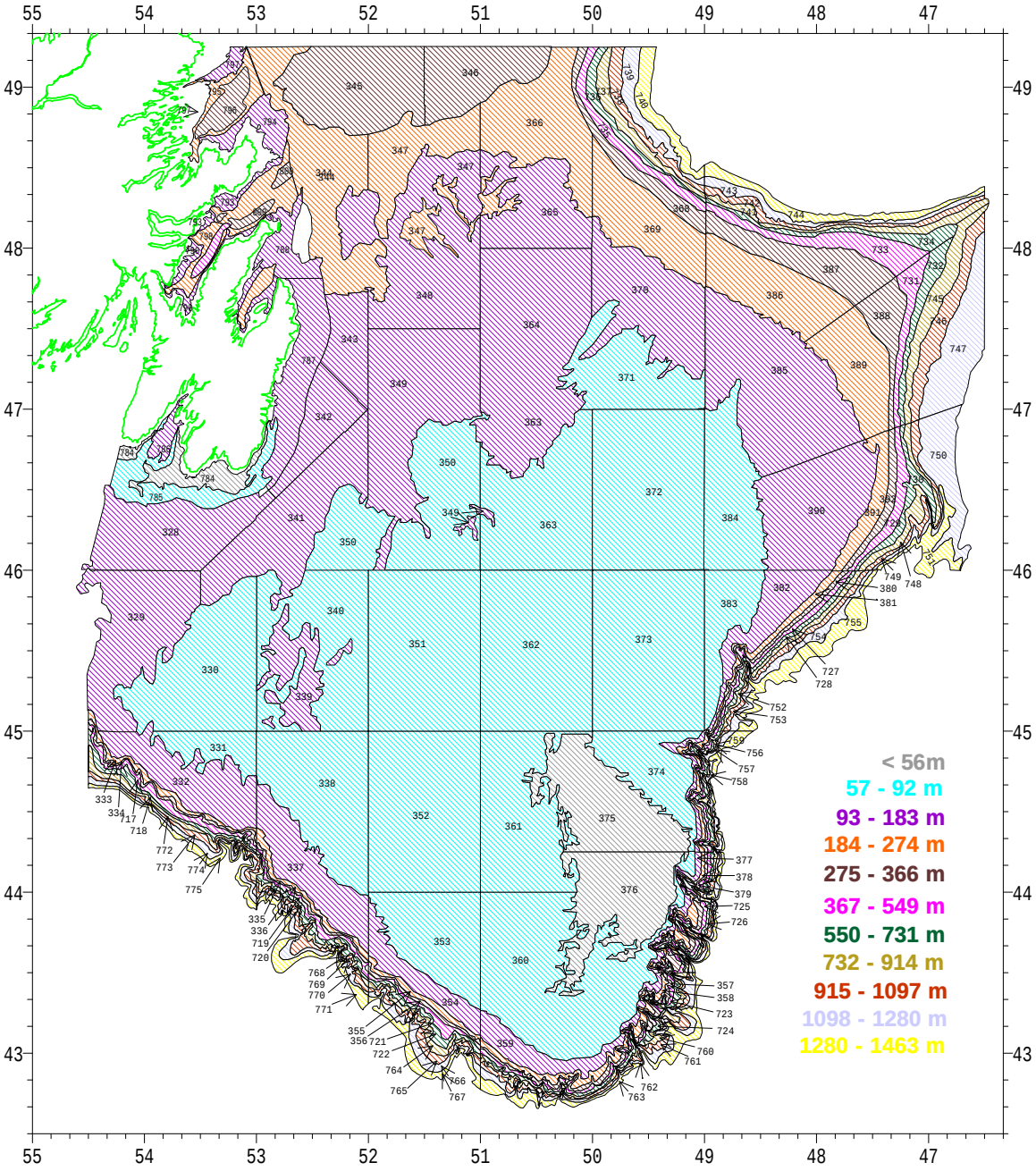


Figure 2. The NAFO 3LNO stratification scheme used in Canadian research bottom trawl survey set allocation.

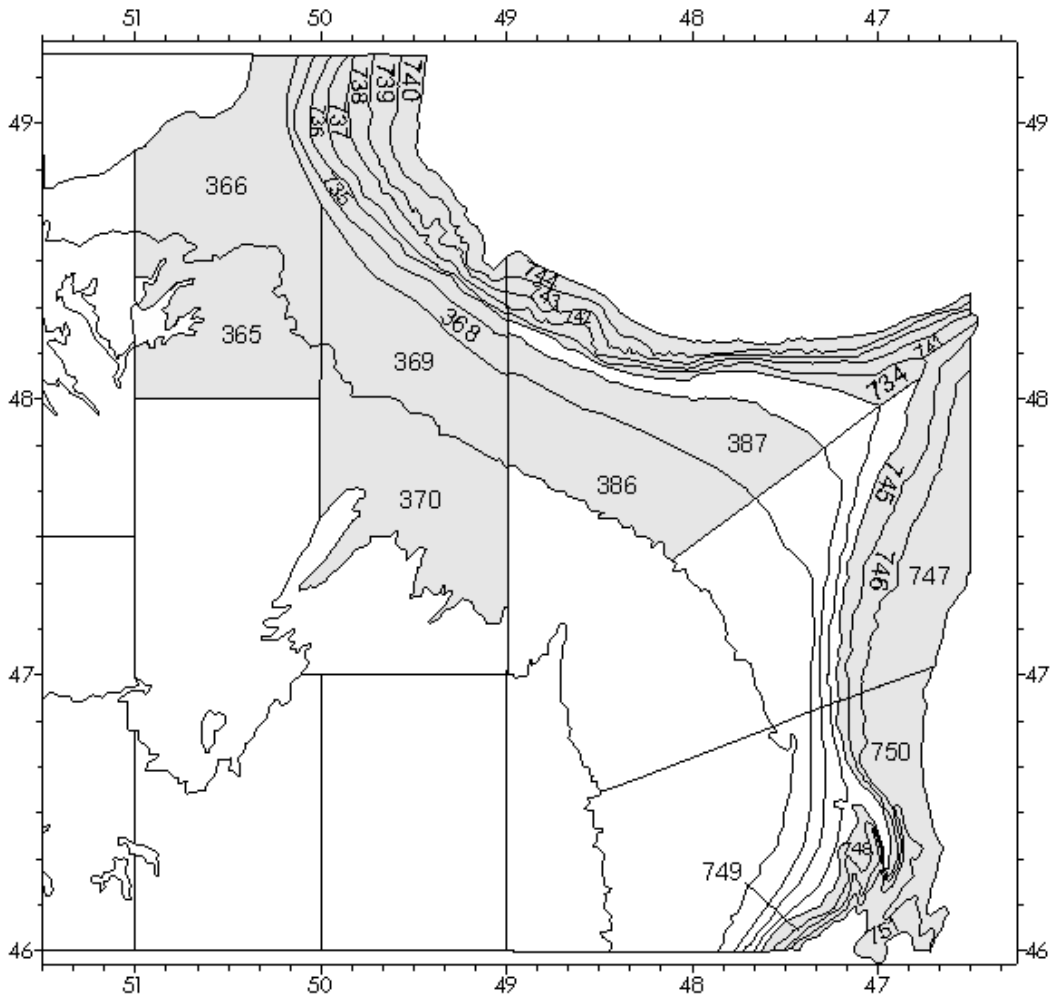


Figure 3. Strata in Div. 3L that were not surveyed (numbered and shaded area) during autumn of 2004.

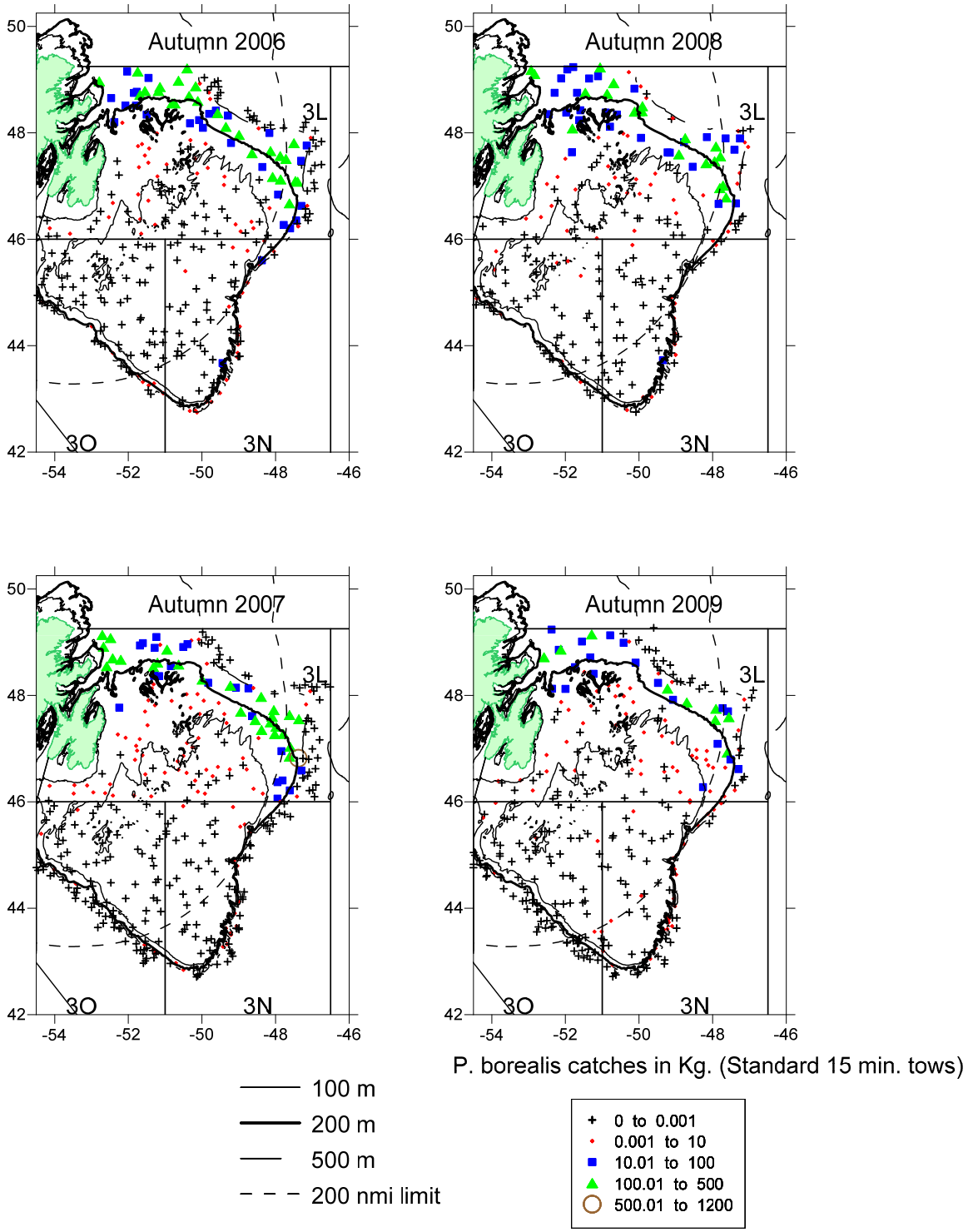


Figure 4. Distribution of NAFO Divs. 3LNO Northern Shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from **autumn** research bottom trawl surveys conducted over the period 2006 – 2009.

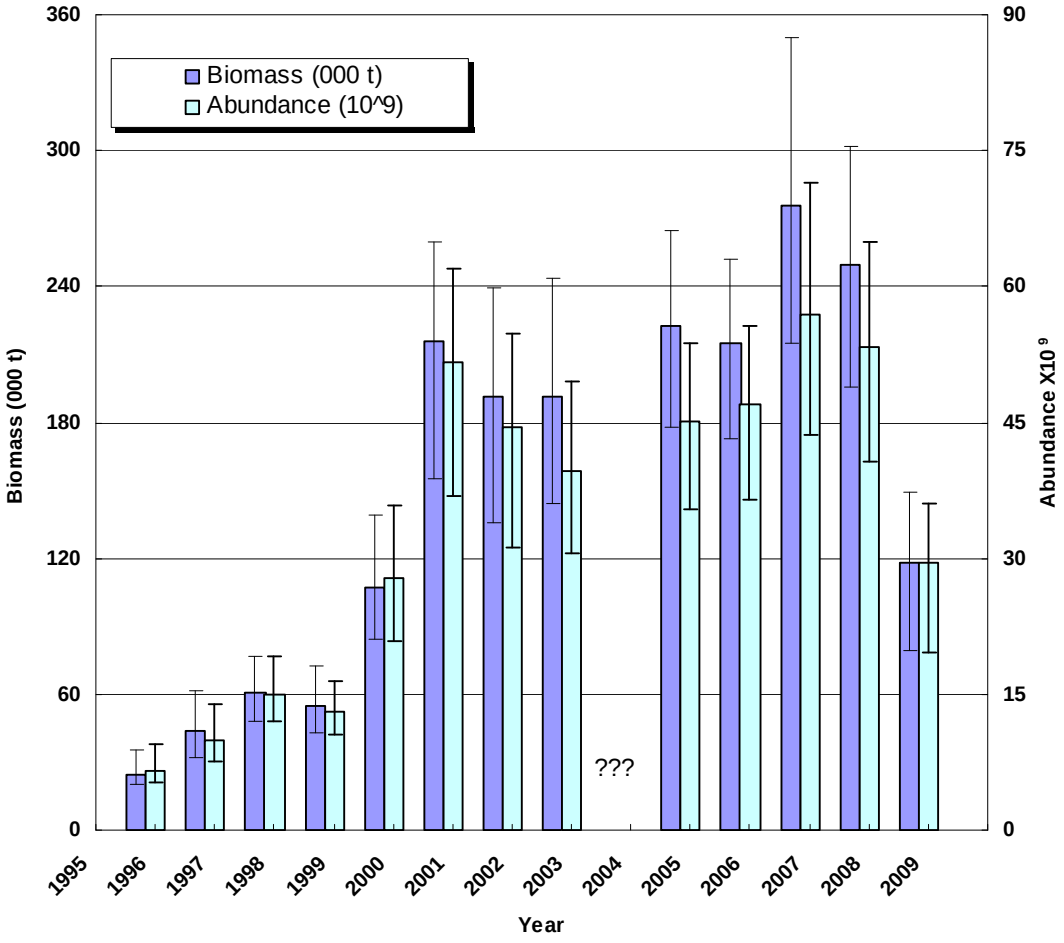


Figure 5. **Autumn** northern shrimp (*Pandalus borealis*) abundance and biomass estimates within NAFO Div. 3LNO. Data were from Canadian multi-species bottom trawl surveys using a Campelen 1800 trawl. (Standard 15 min. tows.)

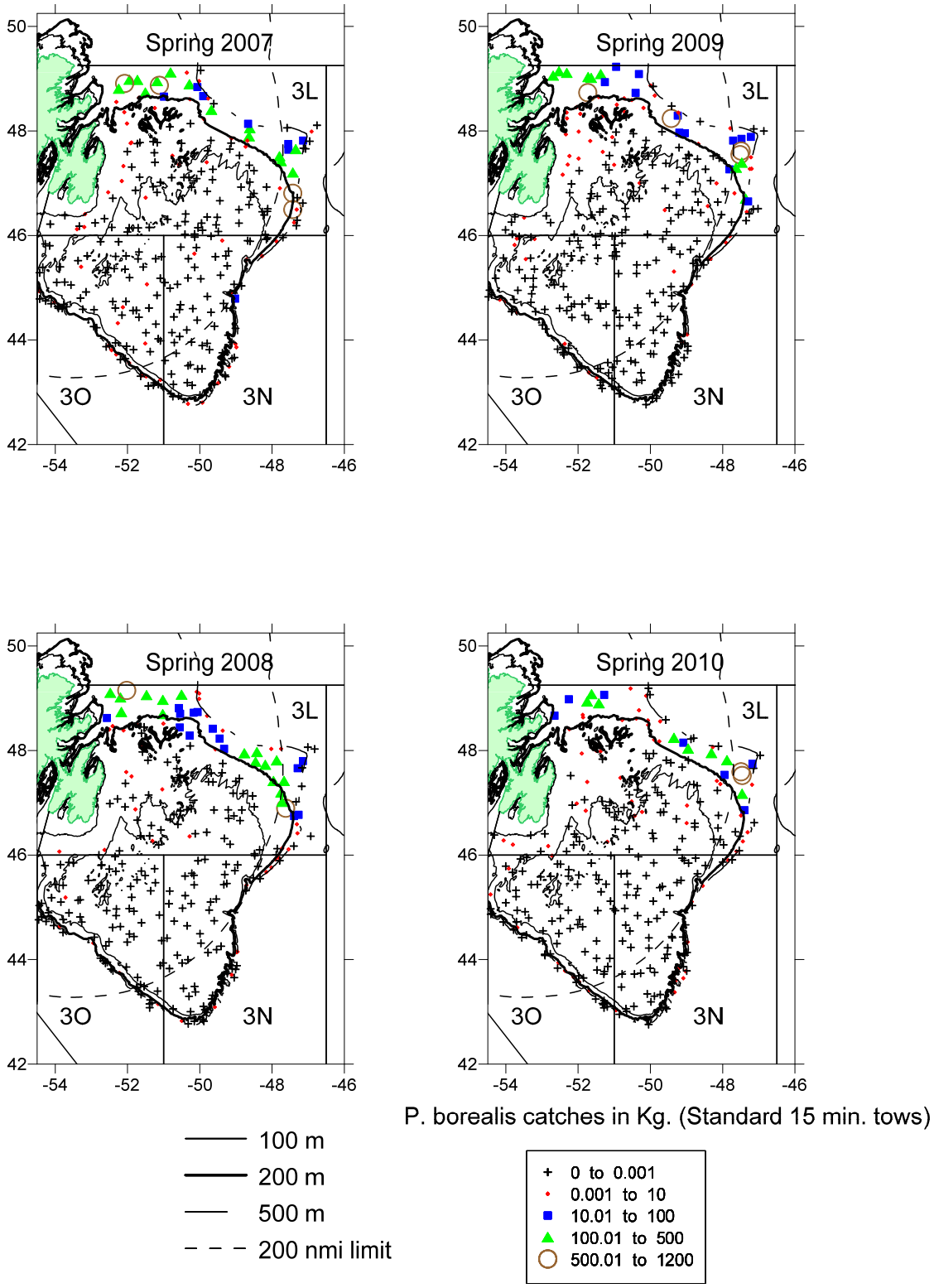


Figure 6. Distribution of NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catches kg/tow) as obtained form **spring** research bottom trawl surveys conducted over the period 2006-2009.

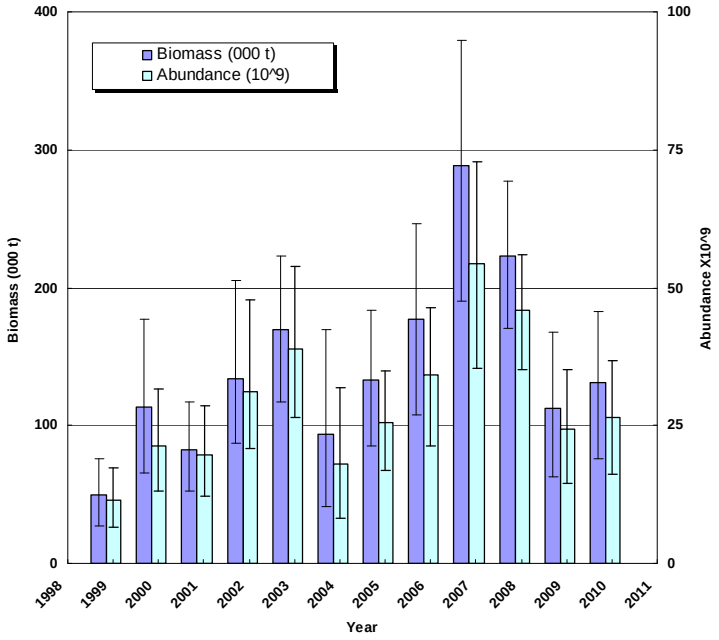
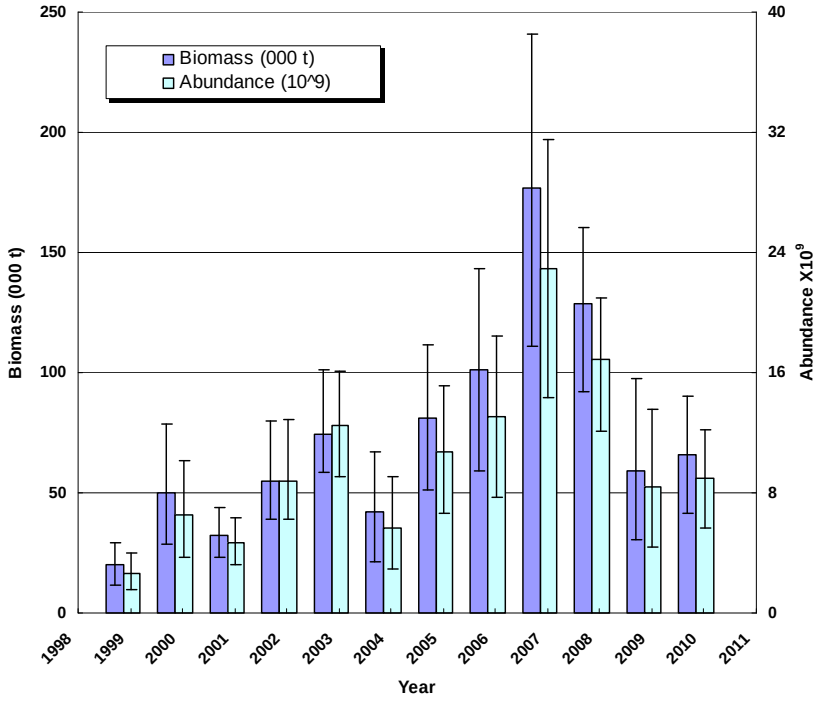
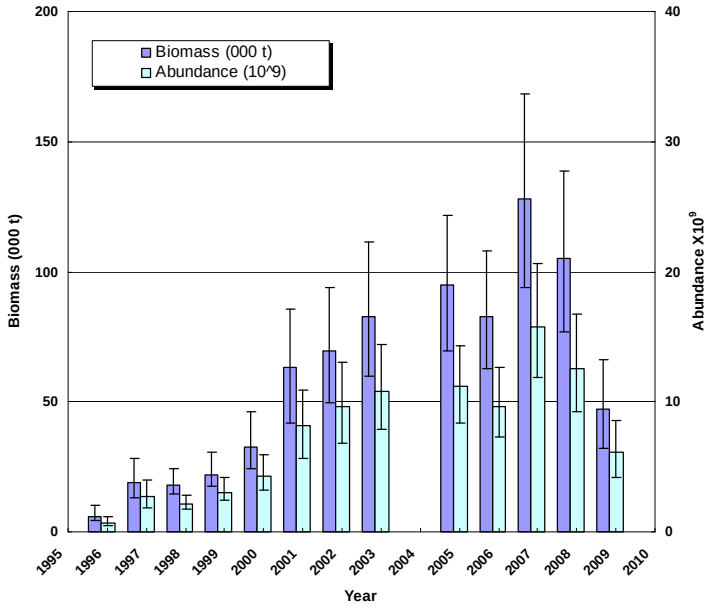


Figure 7. **Spring** northern shrimp (*Pandalus borealis*) abundance and biomass estimates within NAFO Div. 3LNO. Please note that due to operational problems, it was not possible to survey all of Div. 3NO during spring 2006. The indices for 2006 are for Div. 3L only. Data were from Canadian multi-species bottom trawl surveys using a Campelen 1800 trawl. (Standard 15 min. tows.)



A) Spring



B) Autumn

Figure 8. Female spawning stock biomass and abundance estimates as determined using ogmap calculations from spring (A) and autumn (B) Canadian multi-species bottom trawl survey data, 1996 – 2010. The bars represent 95% confidence intervals around the fishable biomass indices.

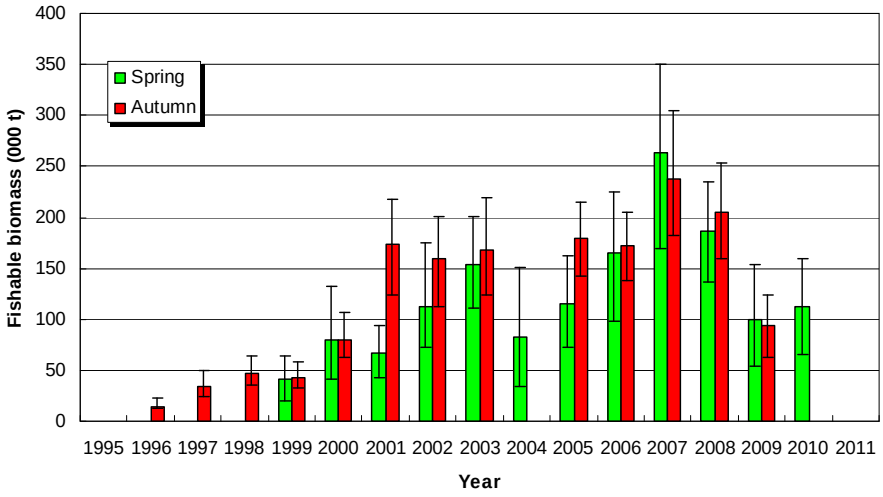


Figure 9. Fishable biomass (t) indices (weight of all females and males with carapace lengths => 17.5 mm) as determined using ogmap calculations from autumn and spring Canadian multi-species bottom trawl survey data, 1996 – 2010. The bars represent 95% confidence intervals around the fishable biomass indices.