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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*) resource within NAFO Divisions 3LNO. A full assessment was completed within Scientific Council during autumn 2011 and management advice was provided for the years 2012 and 2013. The catch table (to September 2012) and biomass indices (autumn 1996-spring 2012) are updated within this report. Preliminary data indicate that 13 041 t of shrimp were taken against an annual TAC of 19 200 t in 2011 while 8 233 t were taken in 2012 against an annual TAC of 12 000 t.

The autumn 2011 3LNO biomass index was estimated to be 73 500 t which was similar to the autumn 2011 index of 75 100 t. The spring 2012 biomass index was estimated to be 58 500 t which was a 16% decrease since 2011 when the index was estimated to be 69 900 t.

The autumn 2011 3LNO female spawning stock biomass (SSB) index was estimated to be 35 600 t, which was similar to the 2010 autumn index which was estimated to be 35 900 t. The spring SSB index decreased by 15% from 32 800 t in 2011 to 28 000 t in 2012.

The autumn 3LNO fishable biomass index was estimated to be 61 500 t in 2011, an increase of 6% from 57 900 t in 2010. The spring fishable biomass index decreased by 16% from 56 300 t in 2011 to 47 400 t in 2012.

Scientific Council considers that the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim} for Northern Shrimp in Div. 3LNO. Using this definition of B_{lim}, the limit reference point is at 19 300 t and therefore the 3LNO Northern Shrimp resource is above B_{lim}. However, the 2011 autumn 3LNO biomass indices are near pre-2002 levels while the 2012 spring biomass indices are the second lowest in each of their respective time series.

Fishery and Management

Catch trends

Catches increased dramatically since 1999, with the beginning of a regulated fishery. Over the period 2002-2009, catches increased from 6 960 to 27 914 t. Preliminary catch records indicate that 13 041 t of shrimp were taken from a 19 200 t TAC in 2011. By September of 2012, 8 233 t of shrimp had been taken from a 12 000 t TAC (Fig. 1). This is down from 11 041 t at the same time in the previous year. As per NAFO agreements, Canadian vessels took most of the catch during each year. Canadian catches increased from 5 402 t in 2002 to 20 147 t in 2008 but have since decreased to 9 197 t in 2011. By September 2012, Canadian vessels took 7 860 t of shrimp. Catches by other contracting parties increased from 1 558 t in 2002 to 8 029 t in 2009 but have since decreased to 3 844 by 2011. Preliminary data indicate that non- Canadian vessels took 373 t of Northern Shrimp by September 2012 while

they took 2 230 t by the same period in the previous year. Table 1 provides a breakdown of catches by contracting party and year since 2002, 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, 2005; 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). 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). Therefore, it was not appropriate to use a multiplicative model to estimate 3L biomass and abundance indices from the autumn 2004 survey. All NAFO Regulatory Area (NRA) strata containing significant quantities of Northern Shrimp have been surveyed consistently throughout the time series.

All important shrimp strata were surveyed in autumn 2011 (Fig 3). The autumn 2011 total biomass index of 73 500 t was similar to the previous year's estimate of 75 100 t (Table 2; Fig. 4). The autumn 2011 total biomass index is 74% below the 2007 peak of 277,600 t and is at a pre-2000 level.

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 indices were not determined for NAFO Divisions 3NO during spring 2006. Historically, at least 95.7% of the spring 3LNO shrimp biomass has been found within Division 3L (Table 3); therefore, the spring 2006 indices were for NAFO Divisions 3L only. All 3LNO strata were surveyed during spring 2012 (Fig. 5). The spring 2012 total biomass index was 58 100 t a drop of approximately 16% from the previous spring when the biomass was 69 900 t (Table 3; Fig 4). The spring total biomass has dropped by 80% between the peak in 2007 and 2012; it is presently at the second lowest level in the time series.

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 11.0 and 32.6% of the estimated total 3LNO biomass (Tables 3 and 4; Figs. 3 and 5; Orr *et al.* 2007). During the autumn, the percent biomass within the NRA ranged between 11.0 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 2). Over the period 1996 – 2011 the overall average autumn percent biomass within the NRA was 16.1%. During the spring, the percent biomass within the NRA ranged between 6.4 and 32.6% (three year running average ranged between 18.7 and 27.5%) (Table 3). Over the period

1999 – 2012 the average spring percent biomass with the NRA was 21.5%. It must be noted that variances around the spring indices are greater than around autumn indices (Tables 4 and 5; and Figs. 3-5).

In all surveys, Division 3N accounted for 0.1-8.1% of the total 3LNO biomass (Tables 2 and 3). Between 0 and 100% 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 2011 3LNO female spawning stock biomass (SSB) index was estimated to be 35 600 t. which was similar to the previous autumn SSB index which was 35 900 t (Table 4; Fig. 4). The spring SSB index decreased by 15% from 32 800 t in 2011 to 28 000 t in 2012 (Table 5; Fig. 4). The 2011 autumn index is at pre-2002 levels while the 2012 spring SSB index is the second lowest in that time series. The spring SSB indices have dropped by 84% since the peak of 177,900 t in 2007.

The autumn 3LNO fishable biomass index was estimated to be 61 500 t in 2011, an increase of 6% from 57 900 t in 2010 (Table 4; Fig. 4). The spring fishable biomass index decreased by 16% from 56 300 t in 2011 to 47 400 t in 2012 (Table 5; Fig. 4). The autumn 2011 fishable biomass index is at a pre-2001 level while the spring 2012 fishable biomass index is the second lowest in that time series. The spring fishable biomass indices have dropped by 82% from 2007 when the indices peaked at 265,000 t.

Scientific Council considers that the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim} for Northern Shrimp in Div. 3LNO. Using this definition of B_{lim}, the limit reference point is at 19 300 t and therefore the 3LNO Northern Shrimp resource is above B_{lim} (Fig. 5). While the autumn female spawning stock biomass was 61 500 t in 2011, it is important to apply caution because both spring and autumn biomass levels have dropped to below 2002 levels. Additionally, exploitation strategies for this resource should take into consideration the importance of shrimp as a forage species. Shrimp and capelin are key forage species in NAFO Divisions 2J3KL. Capelin abundance is at very low levels while some groundfish are increasing. Together this may increase predation pressure on shrimp.

Conclusions

Preliminary data indicate that 13 041 t of shrimp were taken against an annual TAC of 19 200 t in 2011 while 8 233 t were taken in 2012 against an annual TAC of 12 000 t.

The autumn 2011 3LNO biomass index was estimated to be 73 500 t which was similar to the autumn 2011 index which was estimated to be 75 100 t. The spring 2012 biomass index was estimated to be 58 500 t which was a 16% decrease since 2011 when the biomass index was estimated to be 69 900 t.

The autumn 2011 3LNO female spawning stock biomass (SSB) index was estimated to be 35 600 t, which was similar to the 2010 autumn index which was estimated to be 35 900 t which is above the B_{lim} limit reference point which is at 19 300 t. The spring SSB index decreased by 15% from 32 800 t in 2011 to 28 000 t in 2012.

The autumn 3LNO fishable biomass index was estimated to be 61 500 t in 2011, an increase of 6% from 57 900 t in 2010. The spring fishable biomass index decreased by 16% from 56 300 t in 2011 to 47 400 t in 2012.

It is important to note that spring and autumn biomass indices have dropped significantly since 2007 and are now at pre-2002 levels.

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Table 1. Annual nominal catches (t) by country of Northern Shrimp (Pandalus borealis) caught in NAFO Div. 3L between 2002 and September 2012.

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Canada	5,402[1]	9,953[1]	10,313[1]	11,495[1]	17,996[1]	18,027[1]	20,147[2]	19,885[2]	13,212[2]	9,197[2]	7,860[3]	
Cuba	70[2]	81[2]	145[7]	136[2]	239[2]	240[2]	207[7]	334[7]				
Estonia	450[2]	299[2]	271[5]	569[5]	1,098[6]	1,453[6]	1,452[1]	1,607[1]	1,209[1]	1,034[2]		
European Union											134[4]	
Faroe Islands	620[7]	25[1]	1,050[1]	1,055[1]	1,521[1]	1,798[1]	2,273[2]	2,949[2]	2,503[2]	1,446[2]	239[4]	
Germany										301[2]		
Iceland	54[1]	133[1]	104[2]	140[1]	226[8]				184[1]	126[2]		
Latvia	59[1]	144[1]	143[1]	144[1]	244[1]	310[1]	278[1]	330[1]	384[1]	325[2]		
Lithuania	67[2]	142[2]	144[2]	216[1]	486[1]	245[1]	278[2]		340[2]			
Norway	78[1]	145[9]	165[9]	144[9]	272[9]	250[9]	345[1]	672[1]	664[9]			
Poland		145[1]	144[1]	129[1]	245[1]							
Portugal								329[1]	15[1]			
Russia	67[1]		141[1]	146[2]	248[2]	112[2]	278[2]	335[2]	28[2]			
Spain		151[1]	140[1]	154[1]	305[4]	190[1]	187[1]	272[1]	347[1]	292[1]		
St. Pierre and Miquelon	36[1]	144[1]				245[1]	278[1]	334[1]	334[1]			
Ukraine		144[1]	145[1]		121[1]			334[2]				
United States	57[2]	144[2]		136[2]	245[2]	245[2]	278[4]		334[2]	214[5]		
West Greenland		671[2]	299[2]	311[2]	453[10]	455[10]	648[10]	533[10]	536[10]	106[2]		
Estimated additional catch					2,000							
Total catch	6,960	12,321	13,204	14,775	25,696	23,570	26,649	27,914	20,090	13,041	8,233	
TAC (tonnes)	6,000	13,000	13,000	13,000	22,000	22,000	25,000	30,000	30,000	19,200	12,000	9,350

[1] NAFO Statlant21B
[2] NAFO Statlant21A
[3] Canadian Atlantic Quota Report
[4] NAFO monthly records of provisional catch
[5] Observer datasets
[6] Estonian logbook data
[7] Canadian surveillance reports
[8] Icelandic logbook data
[9] Norwegian logbook data
[10] Greenlandic logbook data

Please note that the catch values differ from previous reported values because in the past Canadian catch made use of only Canadian Atlantic Quota Report values; catch for all other countries were updated values provided by various stock experts and using Stantlant21A and B values downloaded on September 4, 2012

Table 2. NAFO Divisions 3LNO *Pandalus borealis* biomass estimates for entire divisions and outside the 200 Nmi limit. Shrimp were collected during the 1996 – 2011 **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	23,056	92.71	4,027	85.11	17.47	17.47
Autumn	1997	3L	43,695	98.64	5,537	91.67	12.67	15.07
Autumn	1998	3L	56,381	92.26	8,961	81.65	15.89	15.34
Autumn	1999	3L	54,871	99.27	8,054	96.39	14.68	14.41
Autumn	2000	3L	106,519	98.88	22,250	98.22	20.89	17.15
Autumn	2001	3L	215,153	99.21	41,077	97.14	19.09	18.22
Autumn	2002	3L	189,077	97.97	35,439	92.39	18.74	19.57
Autumn	2003	3L	186,459	97.01	35,842	91.75	19.22	19.02
Autumn	2004	3L	???	???	???	???	???	???
Autumn	2005	3L	222,704	99.37	26,378	97.40	11.84	15.53
Autumn	2006	3L	215,153	99.21	27,284	96.44	12.68	12.26
Autumn	2007	3L	273,346	98.48	50,038	98.42	18.31	14.28
Autumn	2008	3L	247,874	98.76	33,124	97.92	13.36	14.78
Autumn	2009	3L	117,594	98.65	18,223	97.84	15.50	15.72
Autumn	2010	3L	74,503	99.20	8,860	98.88	11.89	13.58
Autumn	2011	3L	72,590	98.77	7,853	97.50	10.82	12.74
Autumn	1996	3N	2,014	8.10	705	14.89	35.00	35.00
Autumn	1997	3N	705	1.59	503	8.33	71.43	53.21
Autumn	1998	3N	4,732	7.74	2,014	18.35	42.55	49.66
Autumn	1999	3N	503	0.91	302	3.61	60.00	57.99
Autumn	2000	3N	705	0.65	403	1.78	57.14	53.23
Autumn	2001	3N	1,712	0.79	1,208	2.86	70.59	62.58
Autumn	2002	3N	4,027	2.09	2,920	7.61	72.50	66.74
Autumn	2003	3N	4,732	2.46	3,222	8.25	68.09	70.39
Autumn	2004	3N	2,618	???	2,114	???	???	???
Autumn	2005	3N	1,007	0.45	705	2.60	70.00	69.04
Autumn	2006	3N	1,510	0.70	1,007	3.56	66.67	68.33
Autumn	2007	3N	1,309	0.47	805	1.58	61.54	66.07
Autumn	2008	3N	1,309	0.52	705	2.08	53.85	60.68
Autumn	2009	3N	805	0.68	403	2.16	50.00	55.13
Autumn	2010	3N	302	0.40	101	1.12	33.33	45.73
Autumn	2011	3N	503	0.68	201	2.50	40.00	41.11

Table 2 (Continued)

Season	Year	Division	Entire Division: Biomass estimate (t)	Entire Division: Percent by division	Outside 200 Nmi limit: Biomass estimate (t)	Outside 200 Nmi limit: Percent biomass by division	percent biomass in NRA	3 year running average percent biomass in NRA
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	101	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	101	0.05	0	0.00	0.00	0.00
Autumn	2003	3O	201	0.10	0	0.00	0.00	0.00
Autumn	2004	3O	201	???	0	???	???	???
Autumn	2005	3O	101	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
Autumn	2010	3O	0	0.00	0	0.00	0.00	0.00
Autumn	2011	3O	0	0.00	0	0.00	0.00	0.00
	all divisions							
Autumn	1996		24,868	101	4,732	100	19.03	19.03
Autumn	1997		44,299	100	6,041	100	13.64	16.33
Autumn	1998		61,113	100	10,974	100	17.96	16.87
Autumn	1999		55,273	100	8,356	100	15.12	15.57
Autumn	2000		107,728	100	22,653	100	21.03	18.03
Autumn	2001		216,865	100	42,286	100	19.50	18.55
Autumn	2002		193,004	100	38,359	100	19.87	20.13
Autumn	2003		192,198	100	39,064	100	20.32	19.90
Autumn	2004		???		???		???	???
Autumn	2005		224,114	100	27,083	100	12.08	16.20
Autumn	2006		216,865	100	28,291	100	13.05	12.56
Autumn	2007		277,575	99	50,843	100	18.32	14.48
Autumn	2008		250,995	99	33,828	100	13.48	14.95
Autumn	2009		119,205	99	18,626	100	15.63	15.81
Autumn	2010		75,107	100	8,961	100	11.93	13.68
Autumn	2011		73,496	99	8,054	100	10.96	12.84

Table 3. NAFO Divisions 3LNO Pandalus borealis biomass estimates for entire divisions and outside the 200 Nmi limit. Shrimp were collected during the 1999 – 2012 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 werestimated 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	47,823	96.15	10,269	86.44	21.47	
Spring	2000	3L	109,439	95.94	23,962	87.18	21.90	
Spring	2001	3L	83,262	97.07	11,478	99.13	13.78	19.05
Spring	2002	3L	128,971	95.74	34,533	91.47	26.78	20.82
Spring	2003	3L	166,525	97.52	30,103	86.92	18.08	19.55
Spring	2004	3L	92,626	98.40	23,861	97.13	25.76	23.54
Spring	2005	3L	134,106	99.85	14,297	94.67	10.66	18.17
Spring	2006	3L	180,620	???	43,695	???	24.19	20.20
Spring	2007	3L	284,018	97.75	78,732	97.02	27.72	20.86
Spring	2008	3L	224,114	99.73	34,533	99.13	15.41	22.44
Spring	2009	3L	110,949	97.96	36,446	98.64	32.85	25.33
Spring	2010	3L	130,683	99.31	42,084	99.52	32.20	26.82
Spring	2011	3L	69,469	98.71	12,384	100.00	17.83	27.63
Spring	2012	3L	58,495	100.00	3,624	100.00	17.83	25.18
Spring	1999	3N	2,114	4.25	1,611	13.56	76.19	
Spring	2000	3N	4,732	4.15	3,524	12.82	74.47	
Spring	2001	3N	302	0.35	101	0.87	33.33	61.33
Spring	2002	3N	5,839	4.33	3,222	8.53	55.17	54.32
Spring	2003	3N	5,437	3.18	4,531	13.08	83.33	57.28
Spring	2004	3N	1,208	1.28	705	2.87	58.33	65.61
Spring	2005	3N	1,410	1.05	805	5.33	57.14	66.27
Spring	2006	3N	???	???	???	???	???	57.74
Spring	2007	3N	3,121	1.07	2,416	2.98	77.42	67.28
Spring	2008	3N	604	0.27	302	0.87	50.00	63.71
Spring	2009	3N	705	0.62	503	1.36	71.43	66.28
Spring	2010	3N	403	0.31	201	0.48	50.00	57.14
Spring	2011	3N	101	0.14	0	0.00	0.00	40.48
Spring	2012	3N	101	0.17	101	2.70	100.00	50.00

Table 3 (Continued)

Season	Year	Division	Entire Division Biomass estimate (t)	Percent by division	Outside 200 Nmi limit Biomass estimate (t)	Percent biomass by division	percent biomass in NRA	3 year running average percent biomass in NRA
Spring	1999	3O	101	0.20	0	0.00	0.00	
Spring	2000	3O	101	0.09	0	0.00	0.00	
Spring	2001	3O	0	0.00	0	0.00	0.00	0.00
Spring	2002	3O	101	0.07	0	0.00	0.00	0.00
Spring	2003	3O	201	0.12	0	0.00	0.00	0.00
Spring	2004	3O	201	0.21	0	0.00	0.00	0.00
Spring	2005	3O	101	0.07	0	0.00	0.00	0.00
Spring	2006	3O	1,007	???	101	???	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	101	0.00	0	0.00	0.00	0.00
Spring	2011	3O	101	0.00	0	0.00	0.00	0.00
Spring	2012	3O	0	0.00	0	0.00	0.00	0.00
	all divisions							
Spring	1999		49,736	100.61	11,880	100.00	23.89	
Spring	2000		114,070	100.18	27,486	100.00	24.10	
Spring	2001		85,779	97.42	11,578	100.00	13.50	20.49
Spring	2002		134,710	100.15	37,755	100.00	28.03	21.87
Spring	2003		170,753	100.83	34,634	100.00	20.28	20.60
Spring	2004		94,136	99.89	24,566	100.00	26.10	24.80
Spring	2005		134,307	100.97	15,102	100.00	11.24	19.21
Spring	2006		???	???	???	???	???	18.67
Spring	2007		290,562	98.82	81,148	100.00	27.93	19.59
Spring	2008		224,718	100.00	34,835	100.00	15.50	21.71
Spring	2009		113,265	98.58	36,950	100.00	32.62	25.35
Spring	2010		131,589	99.62	42,286	100.00	32.13	26.75
Spring	2011		69,872	99.57	12,384	100.00	17.72	27.49
Spring	2012		58,495	100.17	3,725	2.70	6.37	18.74

Table 4. Northern Shrimp biomass and exploitation rate estimates in NAFO divisions 3LNO from annual autumn Canadian multi-species bottom trawl surveys, 1996 – 2011. Offshore strata only (standard 15 min. tows). Please note that autumn 2004 indices were not determined due to missing strata. Fishable biomass (t) indices were determined as the total biomass of all males and females with carapace lengths => 17.5 mm. All indices were determined using Ogive Mapping calculations.

Autumn

Catch Year	Catch (t)	Survey Year	Fishable biomass (t)			Exploitation rate index Catch/ previous autumn fishable biomass (t)			Female Spawning Stock biomass (t)		
			Lower 95%C.I.	Index	Upper 95% C.I.	Lower 95% C.I.	Index	Upper 95% C.I.	Lower 95% C.I.	Index	Upper 95%C.I.
1993	1,791										
1994	1,865										
1995	70										
1996	175										
1997	485	1996	12,192	14,297	22,381	2.17	3.39	3.98	4,431	5,839	10,370
1998	626	1997	23,660	34,433	49,605	1.26	1.82	2.65	13,129	19,331	28,633
1999	795	1998	34,896	47,219	62,230	1.28	1.68	2.28	14,770	18,324	24,354
2000	5,040	1999	33,506	42,487	58,183	8.66	11.86	15.04	17,679	21,848	31,040
2001	5,647	2000	63,086	80,443	107,526	5.25	7.02	8.95	24,506	32,822	46,565
2002	6,960	2001	124,541	175,083	219,281	3.17	3.98	5.59	42,276	63,932	86,444
2003	12,321	2002	111,755	159,880	200,051	6.16	7.71	11.03	49,887	69,973	94,438
2004	13,204	2003	125,145	169,746	220,489	5.99	7.78	10.55	60,267	83,363	112,258
2005	14,775	2004									
2006	25,696	2005	143,670	179,915	215,959	11.90	14.28	17.89	70,265	95,445	122,528
2007	23,570	2006	138,334	173,774	206,293	11.43	13.56	17.04	63,247	83,162	108,634
2008	26,649	2007	183,439	239,719	306,973	8.68	11.12	14.53	94,710	128,870	169,646
2009	27,914	2008	160,081	206,394	255,224	10.94	13.52	17.44	77,242	105,915	139,442
2010	20,090	2009	63,741	95,042	124,440	16.14	21.14	31.52	32,550	47,722	66,499
2011	13,041	2010	42,427	57,891	74,413	17.53	22.53	30.74	25,774	35,943	48,810
2012	8,233	2011	42,316	61,515	83,272	9.89	13.38	19.46	24,214	35,641	50,018

Table 5. Northern Shrimp biomass estimates in NAFO divisions 3LNO from annual spring Canadian multi-species bottom trawl surveys, 1999 – 2012. Offshore strata only (standard 15 min. tows). Please note that autumn 2004 indices were not determined due to missing strata. Fishable biomass (t) indices were determined as the total biomass of all males and females with carapace lengths => 17.5 mm. 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.

Spring

Survey Year	Fishable biomass (t)			Female Spawning Stock biomass (t)		
	Lower C.I.	Index	Upper C.I.	Lower C.I.	Index	Upper C.I.
1999	20,488	40,876	64,647	11,689	20,136	29,751
2000	41,762	80,544	132,596	28,734	50,642	79,356
2001	43,423	67,355	94,951	23,287	32,721	44,168
2002	73,597	113,668	175,989	38,993	54,971	80,685
2003	111,151	155,450	202,467	58,747	74,906	101,989
2004	34,755	82,759	152,027	21,384	42,084	67,778
2005	73,124	116,587	162,800	51,347	81,349	112,560
2006	94,277	161,692	222,805	59,552	101,888	144,375
2007	160,484	264,990	352,682	111,654	177,902	242,739
2008	171,055	187,970	235,893	92,545	129,474	161,591
2009	55,132	100,579	155,047	30,506	59,401	98,153
2010	66,258	113,366	160,182	41,490	66,247	90,773
2011	26,429	56,280	96,331	16,028	32,822	57,025
2012	25,140	47,420	74,503	15,011	27,989	41,359

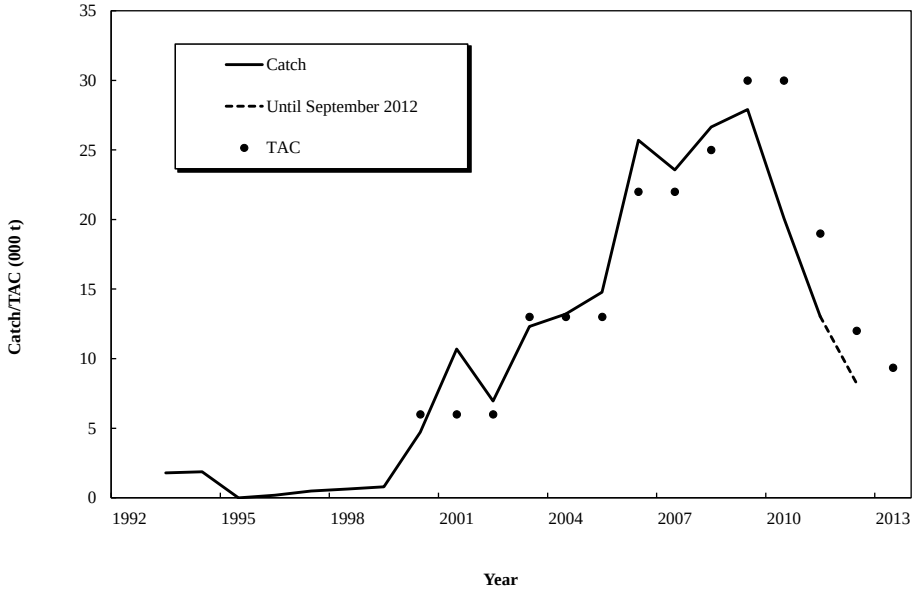

Figure 1. Trends in NAFO Divs. 3LNO Northern Shrimp (*Pandalus borealis*) catch (t) and TAC over the period 1993 – 2013.

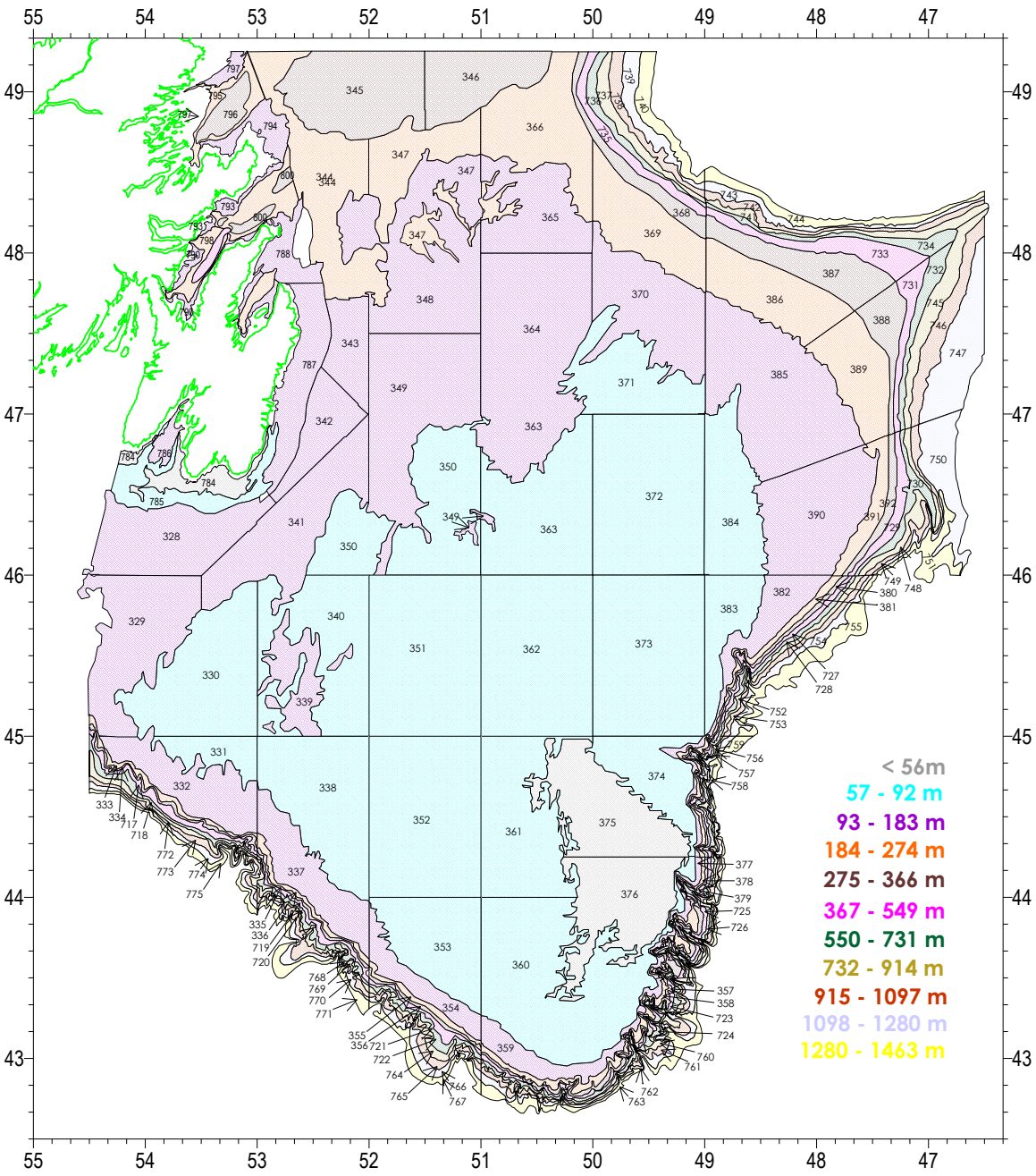

Figure 2. The NAFO 3LNO stratification scheme used in Canadian research bottom trawl survey set allocation.

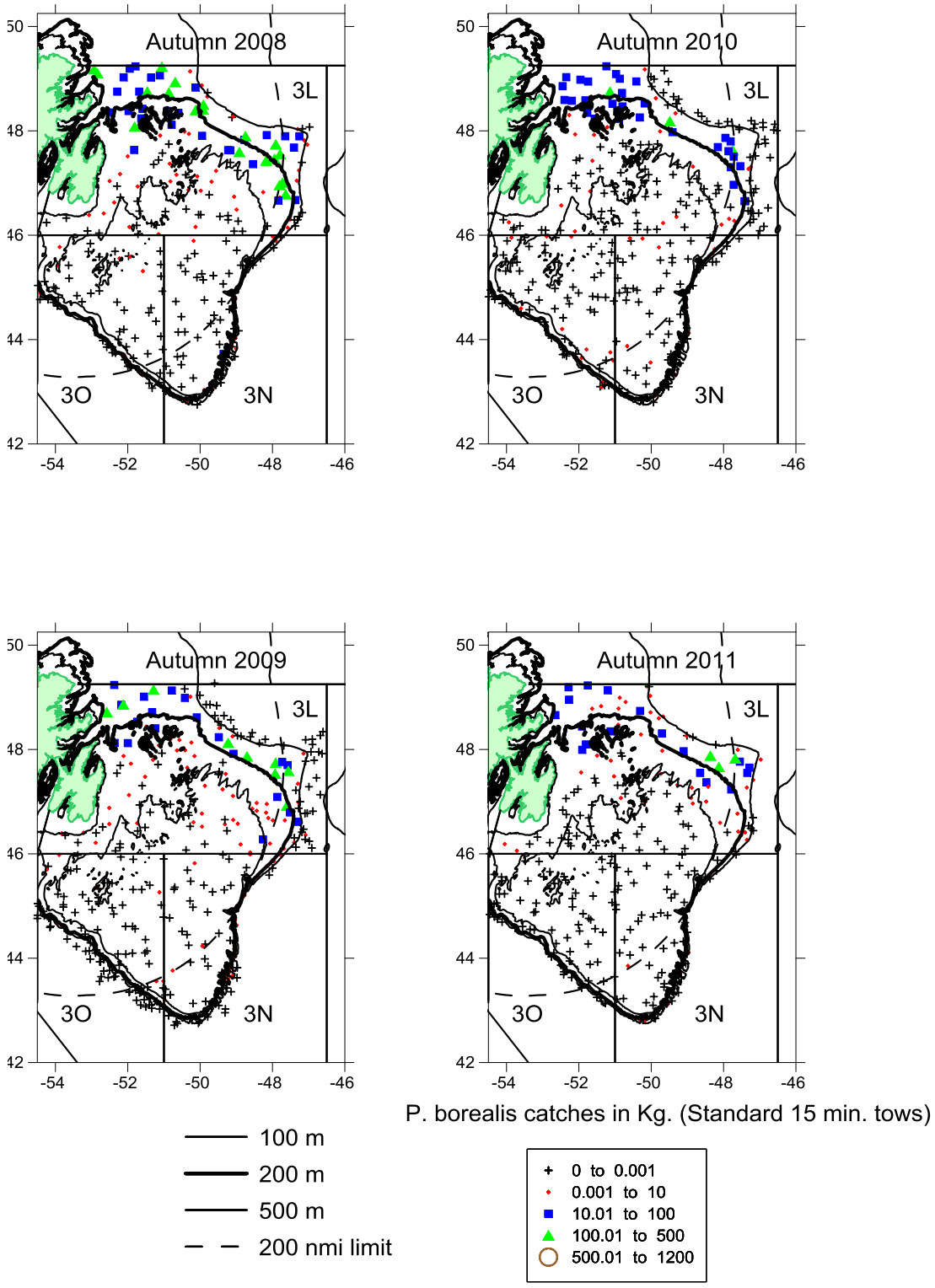

Figure 3. Distribution of NAFO Divs. 3LNO Northern Shrimp (Pandalus borealis) catches (kg/tow) as obtained from autumn research bottom trawl surveys conducted over the period 2008 – 2011.

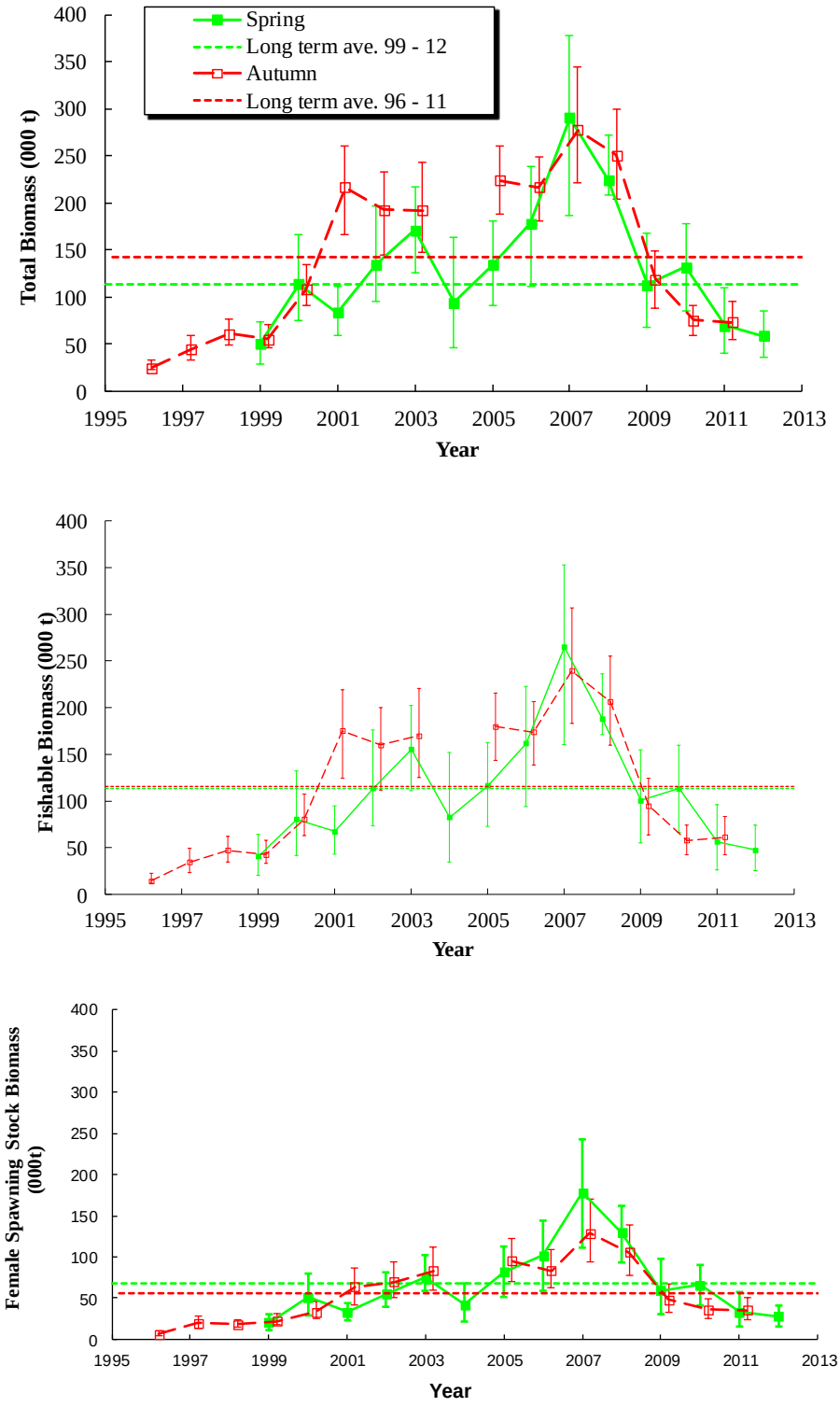

Figure 4. Autumn and spring Northern Shrimp (Pandalus borealis) biomass estimates within NAFO Div. 3LNO. Data were from Canadian multi-species bottom trawl surveys using a Campelen 1800 trawl. (Standard 15 min. tows.)

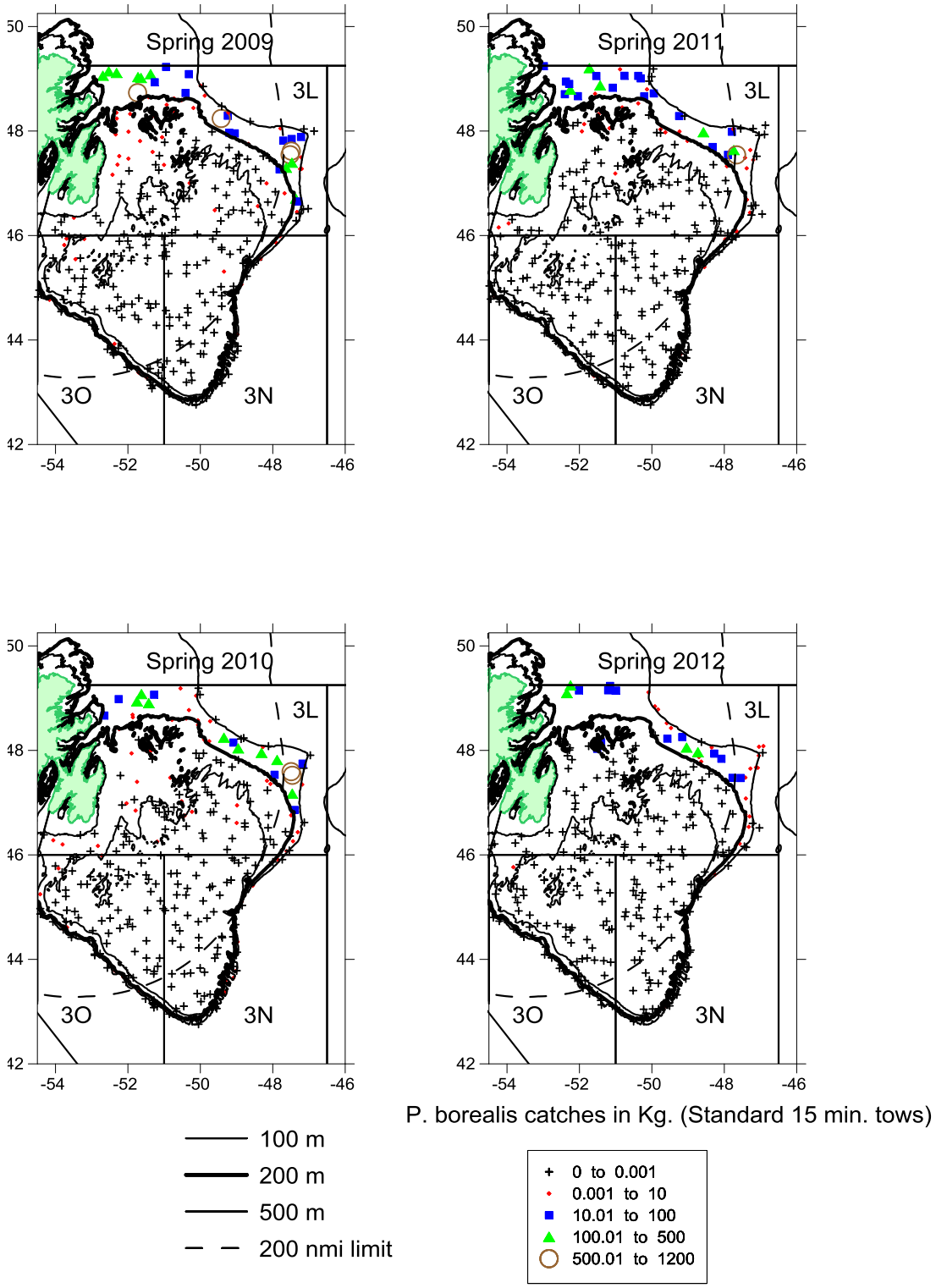

Figure 5. Distribution of NAFO Divs. 3LNO Northern Shrimp (Pandalus borealis) catches (kg/tow) as obtained from spring research bottom trawl surveys conducted over the period 2009 – 2012.

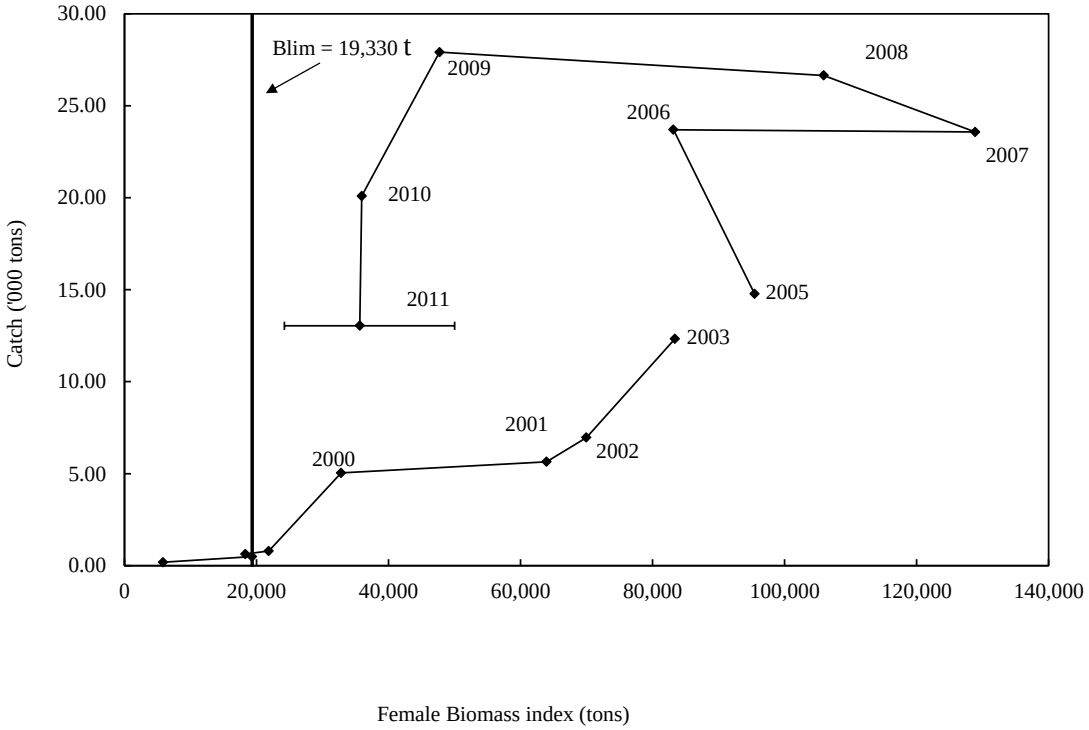

Figure 6. Catch plotted against female biomass index from the Canadian autumn multi-species survey data as derived using Ogmap calculations. Line denoting B_{lim} is drawn where the female biomass is 85% lower than the maximum point (2007 value).