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

By

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Abstract

This interim monitoring report is in response to the NAFO Fishery Commission request that:

"the Scientific Council provide advice in advance of the 2011 Annual Meeting, for the management of Northern shrimp in Div. 3LNO in 2012." (NAFO, 2011).

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 2010, and management advice was provided for the years 2011 and 2012. The catch table (to September 2011) and biomass indices (autumn 1996-spring 2011) are updated within this report. Preliminary data indicate that 20 612 t of shrimp were taken against an annual TAC of 30 000 t in 2010 while 11 041 t were taken in 2011 against an annual TAC of 19 200 t. There is concern that the 2011 TAC may not be taken.

The autumn 2010 3LNO biomass index was estimated to be 75 100 t, a drop of 73% since 2007 when the autumn biomass index was 277,600 t. Similarly, the spring biomass index decreased by 76% from 290,600 t in 2007 to 69 900 t in 2011.

The autumn 2010 3LNO female spawning stock biomass (SSB) index was estimated to be 35 900 t, a drop of 72% since 2007 when the autumn SSB index was 128,900 t. The spring SSB index decreased by 82% from 177,900 t in 2007 to 32 800 t in 2011.

Similarly, the autumn 3LNO fishable biomass index was estimated to be 57 900 t in 2010, a drop of 76% from 239,700 t in 2007. The spring fishable biomass index decreased by 79% from 265,000 t in 2007 to 56 300 t in 2011.

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 but approaching B_{lim}.

Due to the continued drop in 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.

The biomass levels (total, fishable and female spawning stock) dropped by at least 60% between autumn 2007 and spring 2010. Therefore a range of harvest levels were calculated at various levels of exploitation. Fishery Commission set the 2011 and 2012 TACs at 19 200 and 17 000 t respectively. These harvest levels translated into exploitation rates of 16% and 14% respectively based upon the inverse variance weighted average fishable biomass of 120,180 t which was based over the autumn 2008 to spring 2010 surveys.

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 2001-2009, catches increased from 6 967 to 28 544 t. Preliminary catch records indicate that 20 612 t of shrimp were taken from a 30 000 t TAC in 2010. By September of 2011, 11 041 t of shrimp had been taken, down from 12 598 t at the same time in the previous year. There is concern that the 2011 quota of 19 200 t may not be taken. As per NAFO agreements, Canadian vessels took most of the catch during each year. Canadian catches increased from 4 984 t in 2001 to 21 187 t in 2008 but have since decreased to 13 515 t in 2010. By September 2011, Canadian vessels took 8 8111 t of shrimp. While the Canadian large and small vessel shrimp fishing fleets have the capacity to catch the 15,997 t quota for 2011 there is concern that the quota may not be taken for the following reasons:

1. Large vessel catch rates over the 2010 and 2011 fishing seasons were generally lower than in previous years;
2. this fleet concentrated in more northern areas where catch rates were better and operators wished to avoid ice that may be present later in the year; and
3. generally they fish the 3L quota later in the year when catch rates, in that area, are generally much higher. Additionally there are no ice related concerns in this area.
4. The inshore fleet catch rates were good until the end of June. Since July, catch rates have been lower. To date, a much larger proportion of the quota has been harvested than in 2010. Harvesters believe that most of the small vessel quota will be harvested.

Catches by other contracting parties increased from 661 t in 2000 to 7 703 t in 2006 and between 2006 and 2010 have ranged between 5 543 and 8 029 t. Preliminary data indicate that non Canadian vessels took 2 230 t of Northern Shrimp by September 2011 while they took 3 240 t by the same period in the previous year. It is anticipated that the 3 203 t quota for non Canadian vessels will be taken by December 2011. Table 1 provides a breakdown of catches by contracting party and year since 2001, 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). 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). 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 2010 (Fig 3). The autumn 2010 biomass estimate for NAFO Divisions 3LNO was 75 100 t (95% confidence range = 56 600 – 94 300 t) a drop of 73% since 2007 when the biomass was 277,600 t (95% confidence range = 216,100 – 352,200 t) (Table 2; Fig. 4).

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 2011 (Fig. 5). The spring 2011 survey biomass index was 69 900 t (95% confidence bounds = 34 800 – 114,800 t), a drop of approximately 76% since 2007 when the biomass was 290,600 t (95% confidence bounds = 191,500 – 381,800 t) (Table 2; Fig 6).

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. 3 and 5; Orr *et al.* 2007). During the autumn, the percent biomass within the NRA ranged between 11.9 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 – 2010 the overall average autumn percent biomass within the NRA was 16.5%. During the spring, the percent biomass within the NRA ranged between 11.2 and 32.6% (three year running average ranged between 18.7 and 27.5%) (Table 4). Over the period 1999 – 2011 the average spring percent biomass with the NRA was 22.8%. It must be noted that variances around the spring indices are greater than around autumn indices (Table 2; Figs. 3-6).

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 2010 3LNO female spawning stock biomass (SSB) index was estimated to be 35 900 t. a drop of 72% since 2007 when the autumn SSB index was 128,900 t. The spring SSB index decreased by 82% from 177,900 t in 2007 to 32 800 t in 2011 (Table 5; Fig. 7).

Similarly, the autumn 3LNO fishable biomass index was estimated to be 57,900 t in 2010, a drop of 76% from 239,700 t in 2007. The spring fishable biomass index decreased by 79% from 265,000 t in 2007 to 56 300 t in 2011 (Table 6; Fig. 8).

The inverse variance weighted average fishable biomass, determined over the period autumn 2008 – spring 2011, was 66 900 t. Exploitation rates at various TAC options are provided in table 7.

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 but approaching B_{lim} (Fig. 9). The autumn female spawning stock biomass was 35 900 t in 2010.

Exploitation rates over the period 2006 – 2008 have been near 14% and were followed by stock decline. With the present fishable biomass, TACs of 17 000 t and above will result in the exploitation rates of 25% or higher, which is well beyond the range of previous exploitation rates in this fishery. Given recent declines in stock biomass, catches at this level are likely to result in further declines. TACs lower than that will tend to reduce this risk in proportion to the reduction in the exploitation rate. Assessment models have not been developed for this stock; therefore, it is not possible to quantify the absolute magnitude of the risk associated with alternative TAC options.

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 11 041 t of shrimp had been taken in the 3L shrimp fishery by September 2011; however, there is concern as to whether the entire 19 200 t TAC will be taken by the end of December 2011.

The autumn 2010 3LNO biomass index was estimated to be 75 100 t, a drop of 73% since 2007 when the autumn biomass index was 277,600 t. Similarly, the spring biomass index decreased by 76% from 290,600 t in 2007 to 69 900 t in 2011.

The autumn 2010 3LNO female spawning stock biomass (SSB) index was estimated to be 35 900 t. a drop of 72% since 2007 when the autumn SSB index was 128,900 t. The spring SSB index decreased by 82% from 177,900 t in 2007 to 32 800 t in 2011.

Similarly, the autumn 3LNO fishable biomass index was estimated to be 57 900 t in 2010, a drop of 76% from 239,700 t in 2007. The spring fishable biomass index decreased by 79% from 265,000 t in 2007 to 56 300 t in 2011.

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 2001 and September 2011.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Canada	4,984[2]	5,417[2]	10,701[2]	10,560[2]	11,109[2]	18,128[2]	18,316[2]	21,187[2]	20,515[2]	13,515[2]	8,811[2]
Cuba	46[1]	70[1]	81[1]	145[3]	136[1]	239[1]	240[1]	207[3]	334[3]		
EU/Estonia	2,264[4]	450[5]	299[6]	271[6]	569[6]	1,098[10]	1,453[10]	1,458[10]	1607[1]	1,427[10]	
European Union											729[3]
Faroe Islands	2,052[4]	620[5]	25[1]	1,050[1]	1,055[1]	1,521[1]	1,798[1]	2,273[1]	2949[1]	2,503[1]	1,287[3]
France (SPM)	67[1]	36[1]	144[1]				245[1]	278[1]	334[1]	334[1]	
Greenland			671[1]	299[1]	311[1]	453[8]	455[8]	648[8]	533[8]	536[8]	
Iceland	55[7]	54[7]	133[7]	105[7]	140[1]	226[7]				185[3]	
EU/Latvia	67[1]	59[1]	144[1]	143[1]	144[1]	244[1]	310[1]	278[1]	330[1]	384[1]	
EU/Lithuania	67[1]	67[1]	142[1]	144[1]	216[1]	486[1]	245[1]	278[1]		340[1]	
Norway	78[6]	70[6]	145[9]	165[9]	144[3]	272[9]	250[9]	345[1]	672[1]	664[9]	
EU/Poland	54[1]		145[1]	144[1]	129[1]	245[1]					
Portugal	61[5]								329[1]	15[1]	
Russia	67[1]	67[1]		141[1]	146[1]	248[1]	112[1]	278[1]	335[3]	28[1]	
EU/Spain	699[4]		151[1]	140[1]	154[1]	305[6]	190[1]	183[1]	272[11]	347[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]		334[1]	214[3]
Estimated additional catch						2,000[5]					
GRAND TOTAL	10,684	6,967	13,069	13,452	14,389	25,831	23,859	27,691	28,544	20,612	11,041
TAC (tons)	6,000	6,000	13,000	13,000	13,000	22,000	22,000	25,000	30,000	30,000	19,200

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.
11 Spanish logbook dataset

Table 2. Northern Shrimp biomass estimates in NAFO divisions 3LNO from annual spring and 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. 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

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	27,174	49,736	76,708	6,609	11,496	17,418	313
2000	66,157	114,070	177,902	13,239	21,502	31,805	298
2001	53,038	83,061	117,896	12,333	19,852	28,734	300
2002	87,984	134,710	206,092	20,871	31,476	47,984	304
2003	117,997	170,753	224,114	26,549	39,232	54,156	300
2004	41,239	94,136	170,250	8,228	18,121	32,107	296
2005	86,212	134,307	184,748	16,914	25,727	35,097	289
2006	108,130	178,405	247,975	21,405	34,318	46,655	195
2007	191,493	290,562	381,779	35,580	54,675	73,285	295
2008	171,961	224,718	279,085	35,389	46,310	56,361	273
2009	63,277	113,265	168,639	14,528	24,613	35,419	299
2010	76,557	131,589	184,043	16,220	26,625	37,070	288
2011	34,775	69,872	114,775	8,544	15,085	22,905	297

Autumn

Year	Biomass (tons)			Abundance (numbers x 10^6)			Survey
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	20,287	24,868	35,248	5,378	6,625	9,454	304
1997	32,630	44,299	62,361	7,601	9,984	13,964	318
1998	48,649	61,113	77,171	12,031	15,082	19,260	347
1999	43,453	55,273	72,892	10,692	13,085	16,632	313
2000	84,561	107,728	140,147	21,032	28,091	36,074	337
2001	156,356	216,965	261,365	37,141	52,084	62,462	362
2002	136,421	193,004	241,129	31,322	44,777	55,132	365
2003	144,979	192,299	245,055	30,677	39,939	49,927	316
2004	???						
2005	178,707	224,114	266,399	35,731	45,390	54,095	333
2006	174,076	216,865	253,714	36,698	47,354	56,079	312
2007	216,059	277,575	352,179	43,917	57,239	71,946	361
2008	197,131	250,995	303,852	41,017	53,614	65,462	256
2009	80,020	119,205	150,215	19,713	29,688	36,184	315
2010	56,572	75,107	94,337	12,645	17,035	21,092	318

Table 3. NAFO Divisions 3LNO *Pandalus borealis* biomass estimates for entire divisions and outside the 200 Nmi limit. Shrimp were collected during the 1996 – 2010 **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	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	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
	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

Table 4. NAFO Divisions 3LNO *Pandalus borealis* biomass estimates for entire divisions and outside the 200 Nmi limit. Shrimp were collected during the 1999 – 2011 **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 percen 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	100.24	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	99.42	12,384	100.00	17.83	27.63
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	0.36	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	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
	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		83,061	100.61	11,578	100.00	13.94	20.64
Spring	2002		134,710	100.15	37,755	100.00	28.03	22.02
Spring	2003		170,753	100.83	34,634	100.00	20.28	20.75
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

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. Please note that the autumn 2004 survey did not occupy important strata within the shrimp resource therefore no estimations were made for that year. 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.
1999	11,689	20,136	29,751	1,527	2,673	3,983
2000	28,734	50,642	79,356	3,747	6,606	10,199
2001	23,287	32,721	44,168	3,253	4,680	6,404
2002	38,993	54,971	80,685	6,251	8,816	12,978
2003	58,747	74,906	101,989	9,158	12,564	16,169
2004	21,384	42,084	67,778	2,951	5,731	9,156
2005	51,347	81,349	112,560	6,724	10,818	15,193
2006	59,552	101,888	144,375	7,744	13,182	18,525
2007	111,654	177,902	242,739	14,468	23,126	31,765
2008	92,545	129,474	161,591	12,223	17,014	21,082
2009	30,506	59,401	98,153	4,421	8,465	13,692
2010	41,490	66,247	90,773	5,719	8,992	12,283
2011	16,028	32,822	57,025	2,188	4,375	7,661

Spring

Year	Biomass (tons)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	4,431	5,839	10,370	522	665	1,167
1997	13,129	19,331	28,633	1,813	2,738	4,059
1998	14,770	18,324	24,354	1,774	2,148	2,863
1999	17,679	21,848	31,040	2,462	3,020	4,201
2000	24,506	32,822	46,565	3,251	4,278	5,965
2001	42,276	63,932	86,444	5,683	8,193	10,994
2002	49,887	69,973	94,438	6,848	9,661	13,119
2003	60,267	83,363	112,258	7,946	10,888	14,538
2004						
2005	70,265	95,445	122,528	8,393	11,223	14,438
2006	63,247	83,162	108,634	7,355	9,703	12,766
2007	94,710	128,870	169,646	11,971	15,888	20,790
2008	77,242	105,915	139,442	9,284	12,656	16,874
2009	32,550	47,722	66,499	4,243	6,214	8,594
2010	25,774	35,943	48,810	3,235	4,458	6,038

Autumn

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 – 2011. All indices were estimated using Ogmap calculations. Please note that the autumn 2004 survey did not occupy important strata within the shrimp resource therefore no estimations were made for that year. 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 (numbers x 10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1999	20,488	40,876	64,647	3,473	7,103	11,538
2000	41,762	80,544	132,596	7,044	13,921	22,804
2001	43,423	67,355	94,951	7,978	12,884	18,747
2002	73,597	113,668	175,989	14,166	22,323	35,168
2003	111,151	155,450	202,467	20,428	29,220	38,510
2004	34,755	82,759	152,027	6,186	15,094	28,643
2005	73,124	116,587	162,800	12,011	19,072	26,771
2006	94,277	161,692	222,805	14,911	26,121	36,728
2007	160,484	264,990	352,682	26,529	40,625	54,246
2008	171,055	187,970	235,893	23,328	30,949	39,326
2009	55,132	100,579	155,047	9,801	17,501	26,026
2010	66,258	113,366	160,182	11,196	19,677	28,009
2011	26,429	56,280	96,331	4,583	9,807	16,904

Spring

Year	Biomass (tons)			Abundance (numbers x 10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	12,192	14,297	22,381	2,331	2,777	4,257
1997	23,660	34,433	49,605	4,603	6,488	9,532
1998	34,896	47,219	62,230	6,713	9,253	12,142
1999	33,506	42,487	58,183	5,656	7,325	9,965
2000	63,086	80,443	107,526	12,676	16,332	21,908
2001	124,541	175,083	219,281	25,130	35,359	43,574
2002	111,755	159,880	200,051	21,515	31,249	39,205
2003	125,145	169,746	220,489	22,844	30,866	39,779
2004						
2005	143,670	179,915	215,959	25,472	31,528	37,292
2006	138,334	173,774	206,293	24,163	30,386	35,369
2007	183,439	239,719	306,973	31,100	39,905	51,025
2008	160,081	206,394	255,224	28,855	36,731	45,487
2009	63,741	95,042	124,440	11,306	17,247	22,613
2010	42,427	57,891	74,413	7,122	9,549	12,122

Autumn

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 2009	95 042	31 301	9.70035E-05	1.02E-09	0.150
Spring 2010	113 366	47 108	5.10845E-05	4.51E-10	0.067
Autumn 2010	57 891	15 464	0.000242071	4.18E-09	0.617
Spring 2011	56 280	29 852	6.31567E-05	1.12E-09	0.166
Grand total			4.53315E-04	6.775E-09	1.00

Inverse variance weighted average fishable biomass = 4.53315E-04/6.775E-09
= 66 911 t

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

inverse variance weighted average fishable biomass	7.47%	14.95%	25.41%	28.69%	44.84%
66,911	5,000	10,000	17,000	19,200	30,000

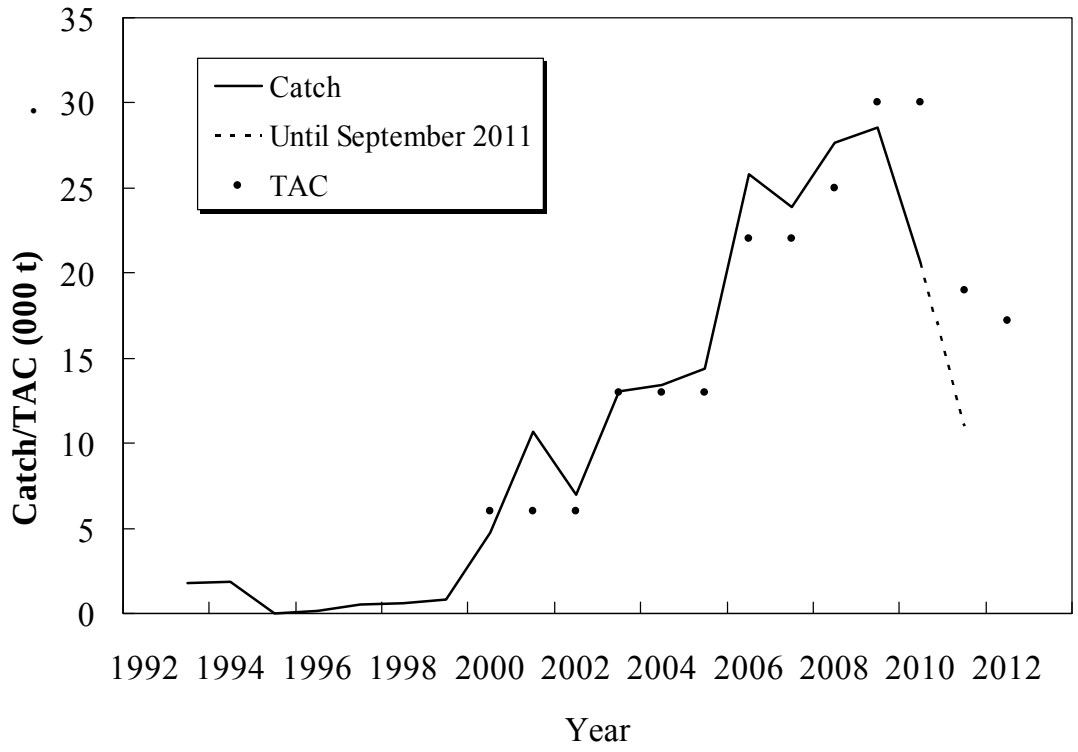

Figure 1. Trends in NAFO Divs. 3LNO Northern Shrimp (*Pandalus borealis*) catch (t) and TAC over the period 1993 – 2010.

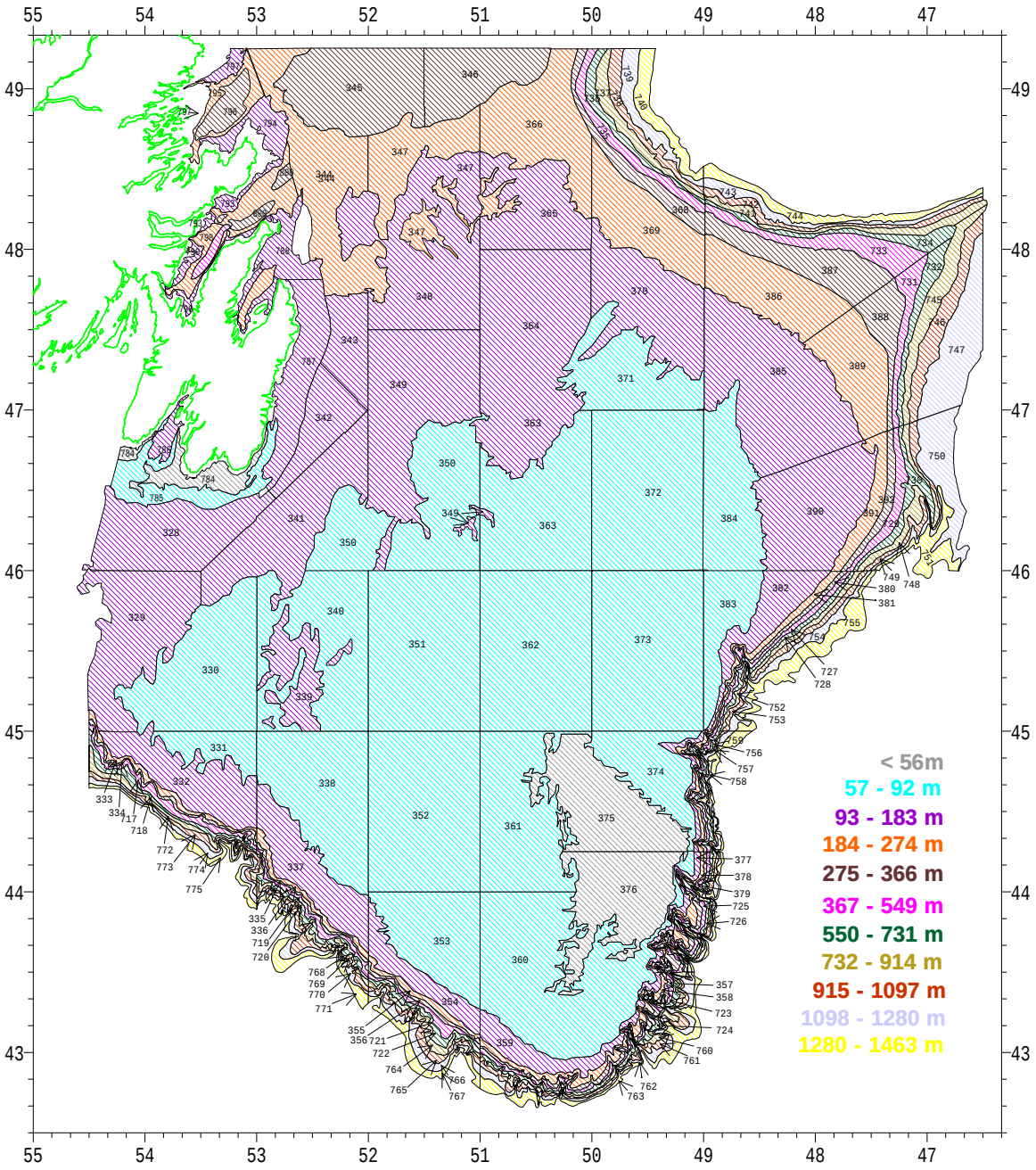

Figure 2. The NAFO 3LNO stratification scheme used in Canadian research bottom trawl survey set allocation.

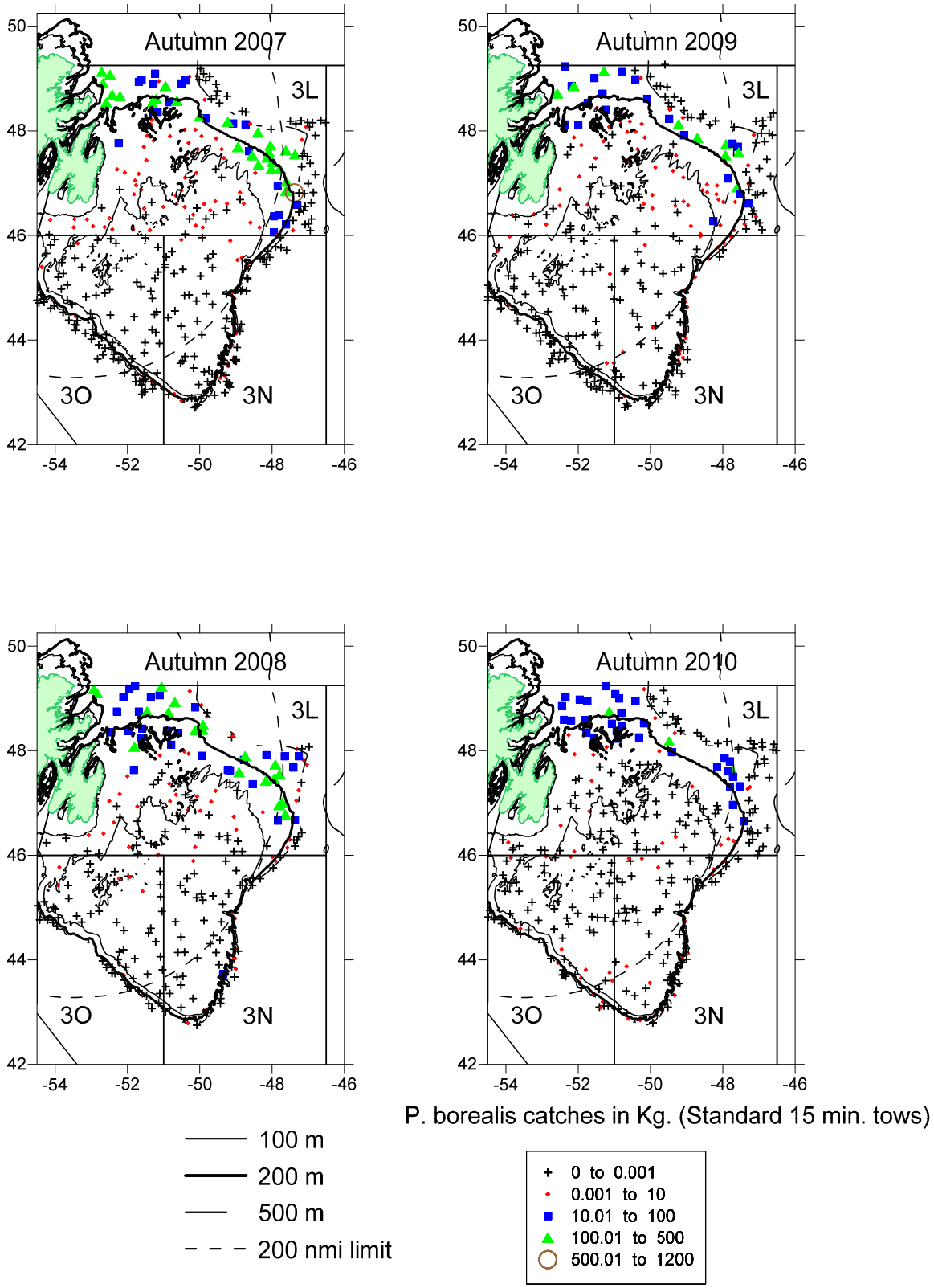

Figure 3. Distribution of NAFO Divs. 3LNO Northern Shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from **autumn** research bottom trawl surveys conducted over the period 2007 – 2010.

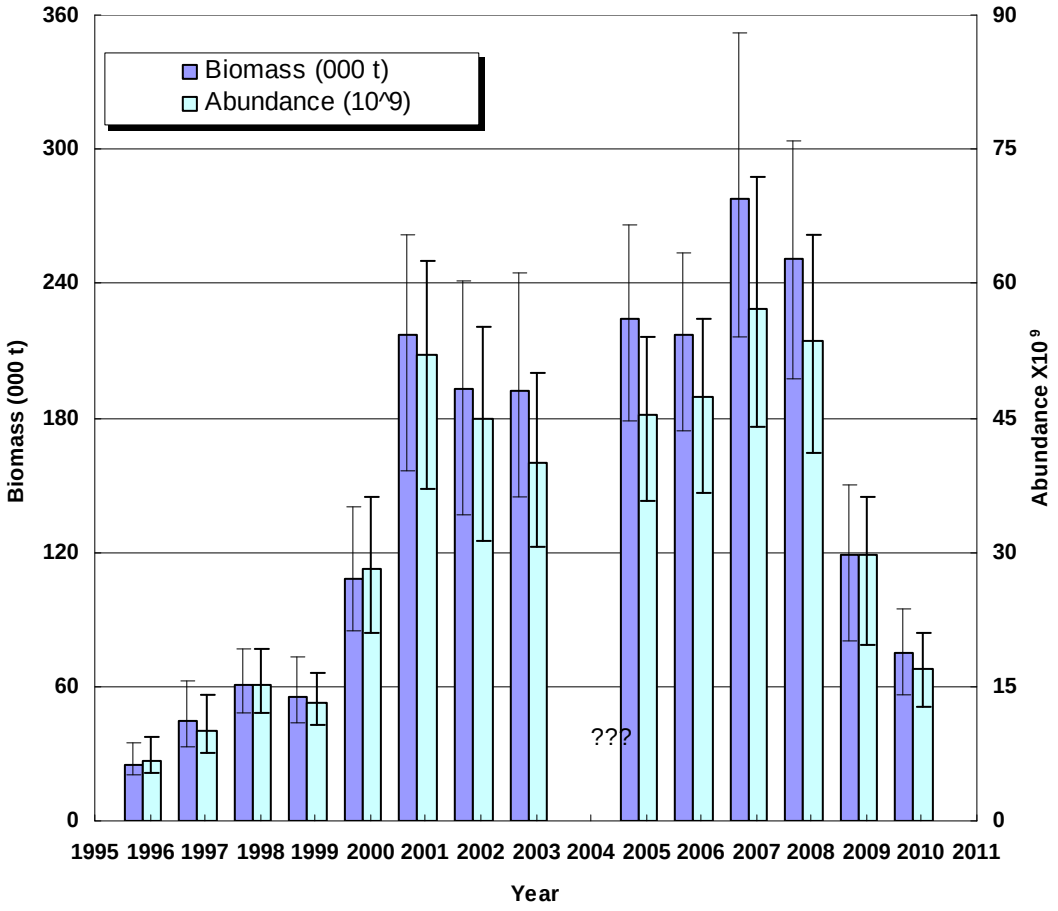

Figure 4. **Autumn** Northern Shrimp (*Pandalus borealis*) abundance and biomass estimates within NAFO Div. 3LNO. Data were from Canadian multi- species bottom trawl surveys using a Campelen 1800 trawl. (Standard 15 min. tows.)

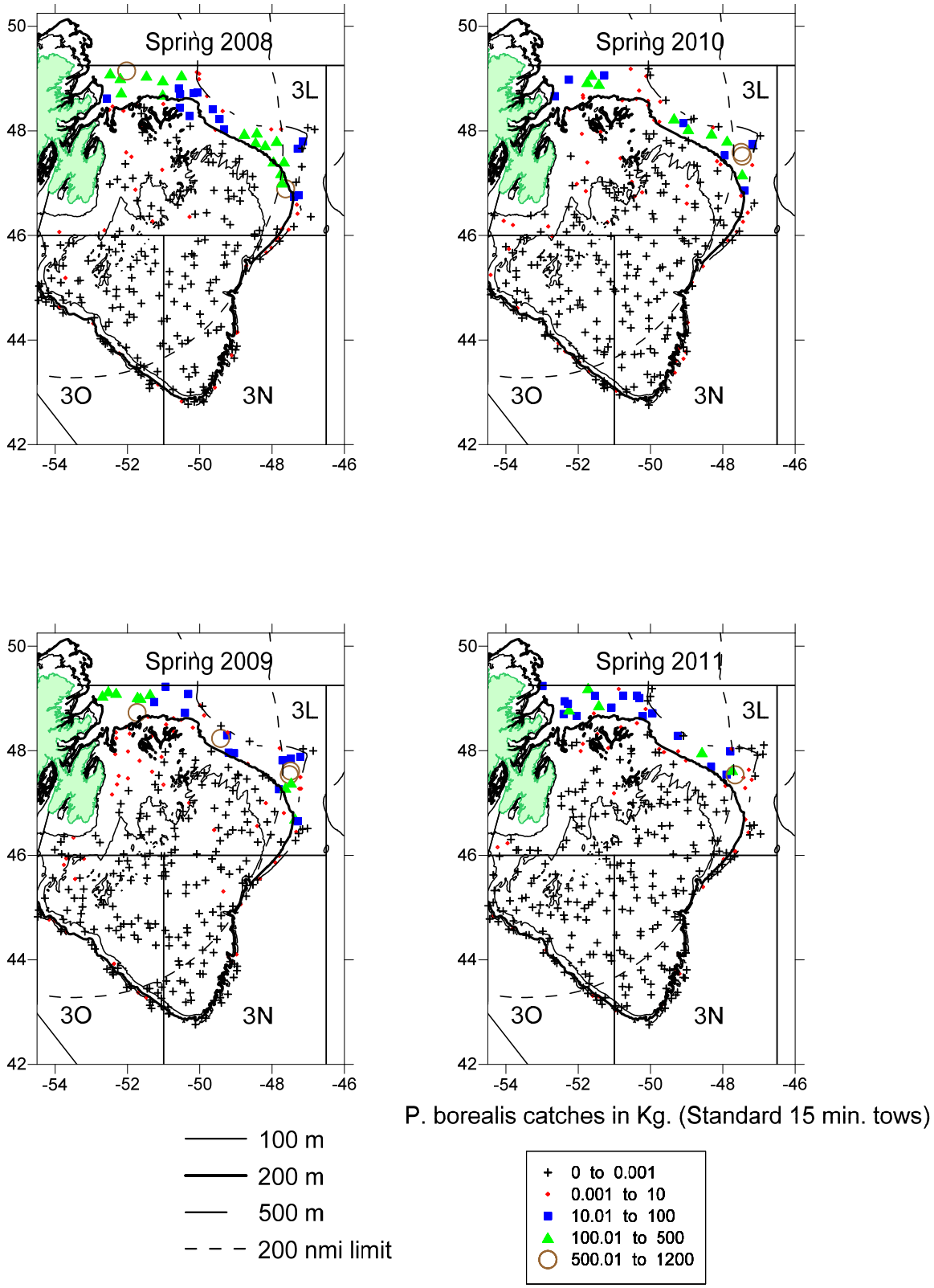

Figure 5. Distribution of NAFO Div. 3LNO Northern Shrimp (*Pandalus borealis*) catches kg/tow) as obtained form **spring** research bottom trawl surveys conducted over the period 2008-2011.

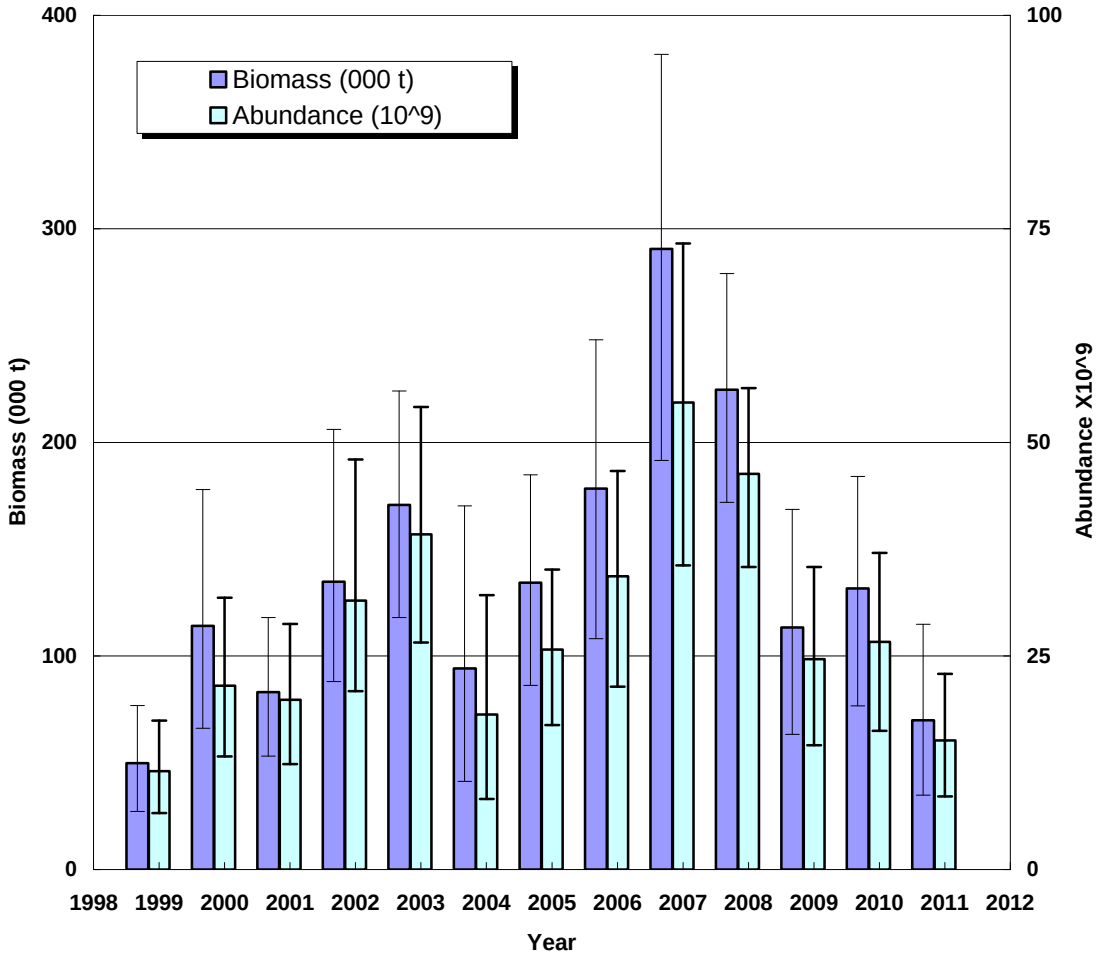

Figure 6. **Spring** Northern Shrimp (*Pandalus borealis*) abundance and biomass estimates within NAFO Div. 3LNO. Please note that due to operational problems, it was not possible to survey all of Div. 3NO during spring 2006. The indices for 2006 are for Div. 3L only. Data were from Canadian multi-species bottom trawl surveys using a Campelen 1800 trawl. (Standard 15 min. tows.)

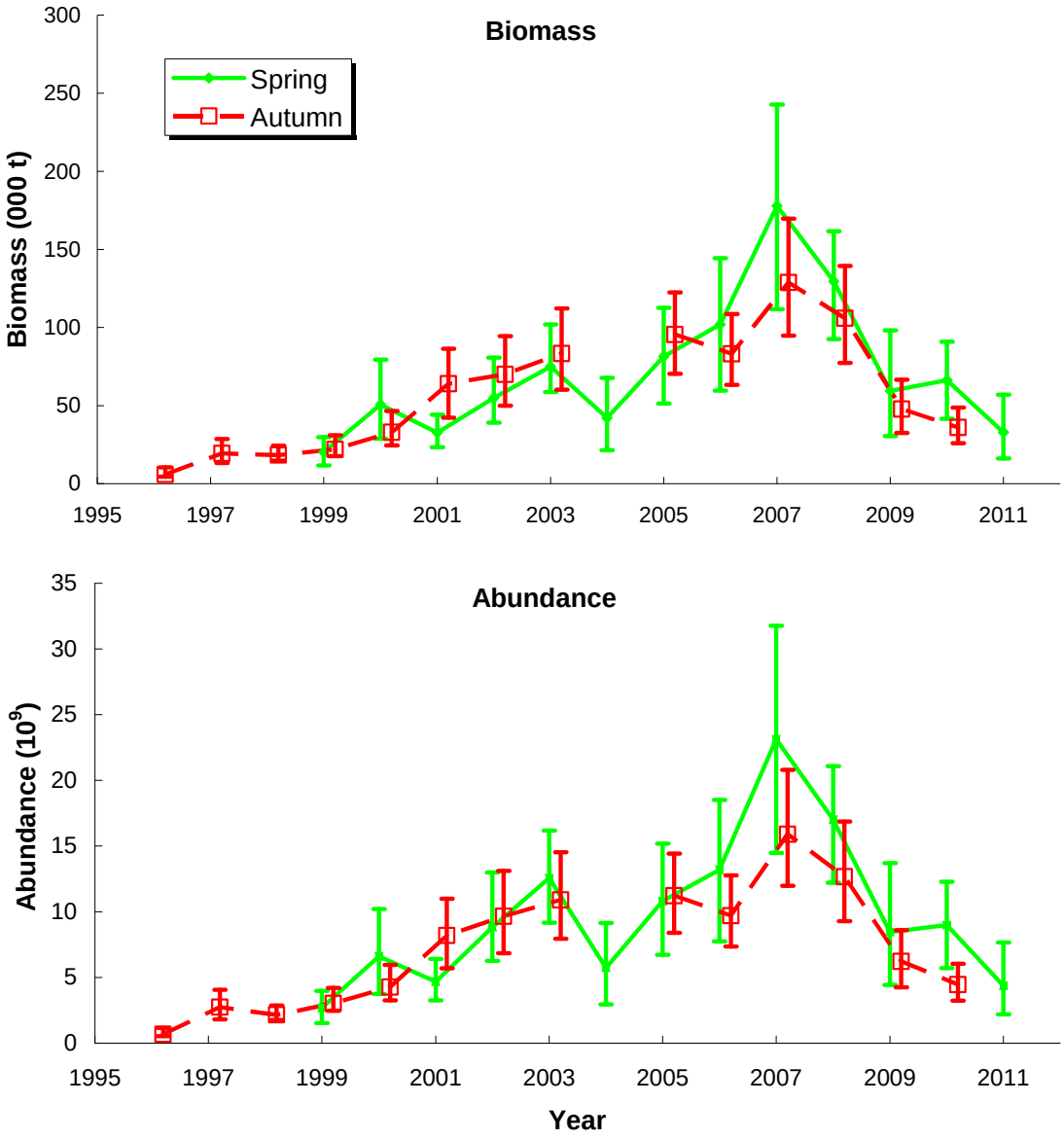

Figure 7. Female spawning stock biomass and abundance estimates as determined using ogmap calculations from spring and autumn Canadian multi-species bottom trawl survey data, 1996 – 2011. The bars represent 95% confidence intervals around the spawning stock biomass indices.

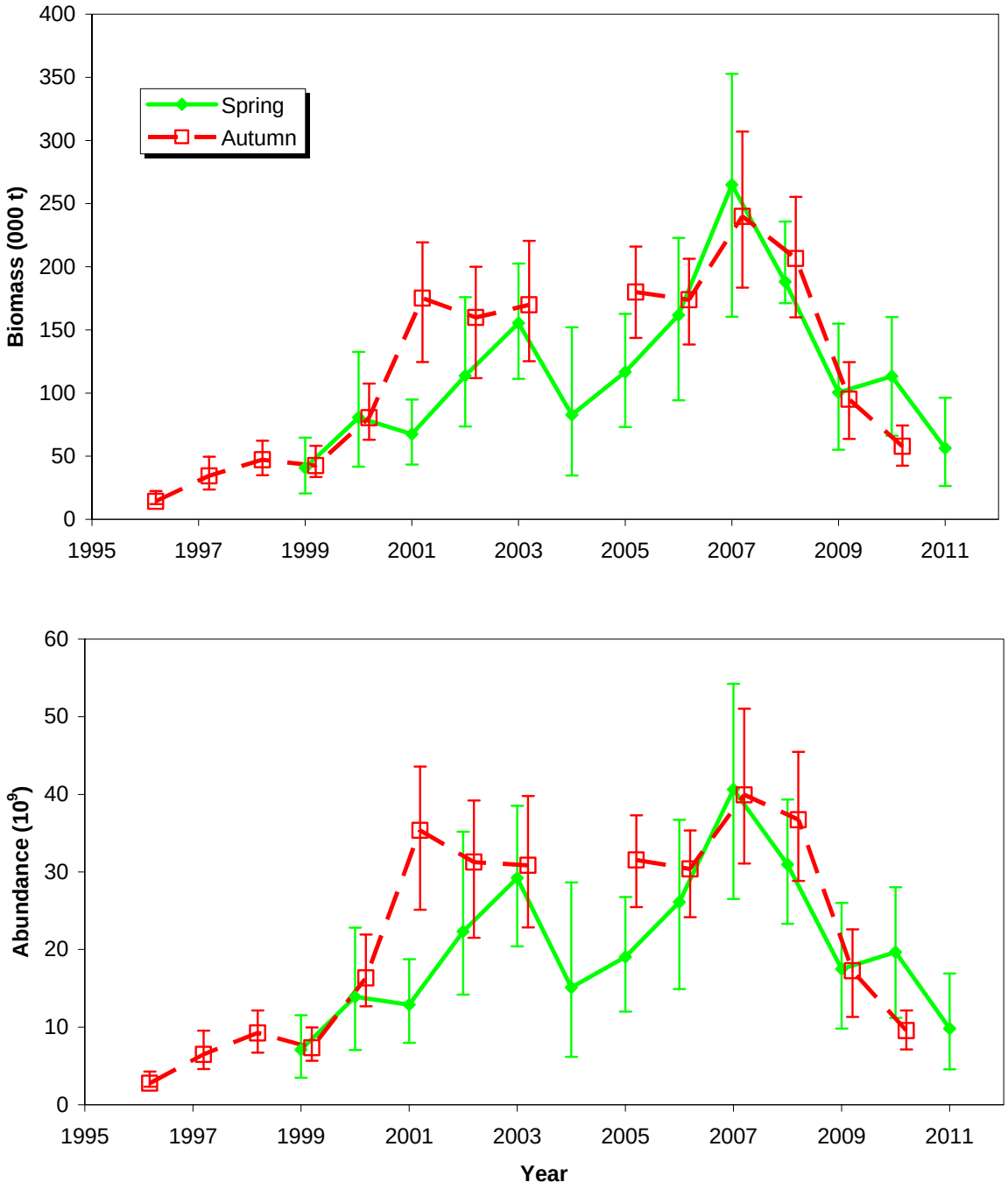

Figure 8. Fishable biomass (t) indices (weight of all females and males with carapace lengths => 17.5 mm) as determined using ogmap calculations from autumn and spring Canadian multi-species bottom trawl survey data, 1996 – 2011. The bars represent 95% confidence intervals around the fishable biomass indices.

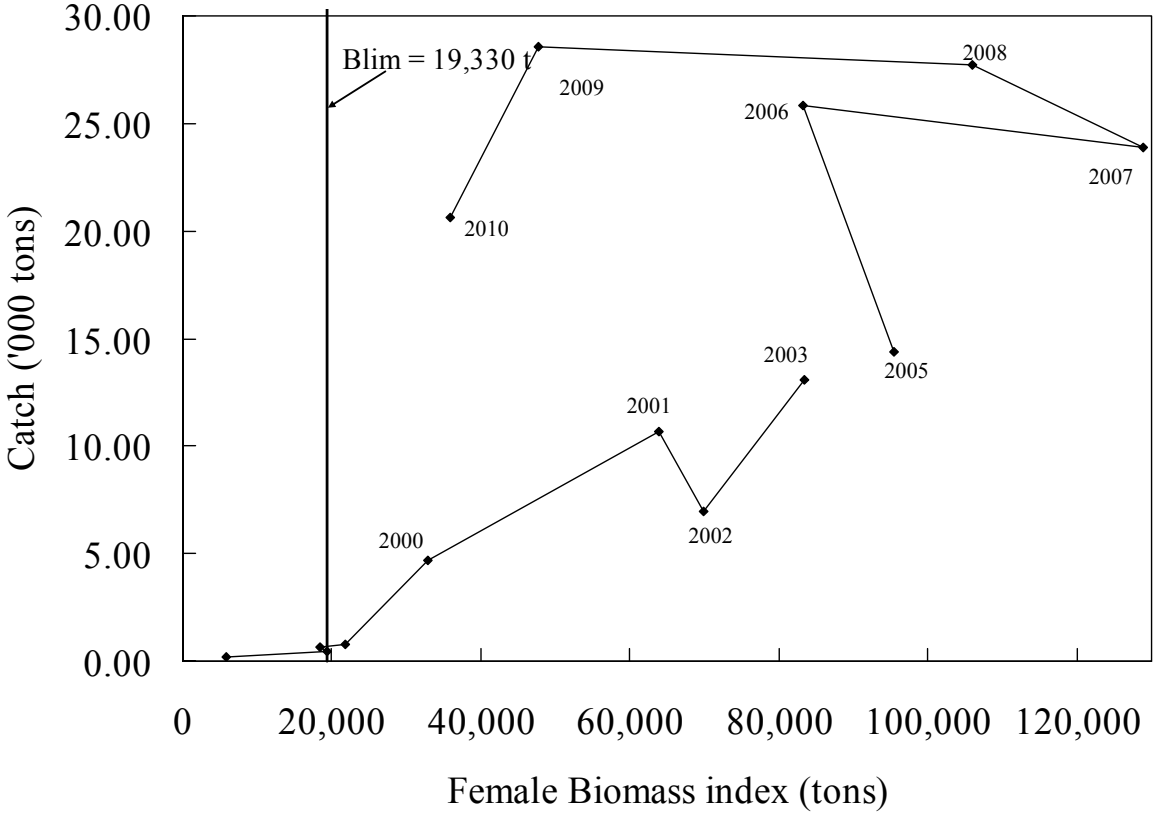

Figure 9. Catch plotted against female biomass index from the Canadian **autumn** multi-species survey data as derived using Ogmap calculations. Line denoting B*lim* is drawn where the female biomass is 85% lower than the maximum point (2007 value).