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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 2004, and management advice was provided for the years 2005 and 2006. The catch table (to June 2005) and biomass estimates (autumn 1995-spring 2005) are updated within this report. Preliminary data indicate that 12 760 and 12 864 tons of shrimp were taken against annual TACs of 13 000 tons in 2004 and 2005, respectively. The autumn 2004 biomass index could not be estimated because the Canadian autumn 2004 research survey did not cover all strata in NAFO Div. 3L. Historically 90-99% of the biomass had been attributed to NAFO Div. 3L and an analysis of the Div. 3L data indicated that between 25 and 61% of the Div. 3L biomass are normally found in the missing strata. As a corollary, strata that had been consistently fished in 3L had been analysed. The autumn 2004 biomass index, within consistently fished Div. 3L strata, was 97 000 tons (95% C.I. = ± 22 000 tons), the second highest value in the time series. The spring 2004 biomass index was 156 000 tons (95% C.I. = ± 67 000 tons), the third highest in the time series. However, indices derived from spring surveys are thought to be less precise because the confidence intervals are sometimes broad with negative lower confidence limits.

Plots confirmed that a substantial portion of the research biomass is often taken from the strata that were missed during the autumn 2004 survey and that the distribution of shrimp catches varies both seasonally and annually.

Fishery and Management

TAC regulation

Due to the highly variable nature of the spring survey indices, Scientific Council (SC) felt it was necessary to base advice on a new methodology, as follows. 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 tons. Had this new method been used in 2003, it is likely that the advised TAC calculated for 2005 would have been around 22 000 tons instead of the 13 000 tons actually advised. However, SC 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 tons was in place for 3 years, however the current TAC of 13 000 tons had been in place since the beginning of 2003. A two year period was insufficient to determine the impact of a 13 000 tons 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 tons. At that time, 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. During the November 2004 shrimp assessment, SC decided that this advice should extend through 2006, and that the advice would be reviewed in September 2005 (NAFO, 2004).

Catch trends

Catches increased dramatically since 1999, with the beginning of a regulated fishery. Since then, sixteen contracting nations have exercised their privileges to fish shrimp in Div. 3L (Table 1). Over the period 2000-2005, catches were 5 043, 10,701, 6 977, 12 412, 12 760 and 12 864 tons, respectively. As per NAFO agreements, Canadian vessels took most of the catch during each year. Canadian catches increased from 4 382 tons in 2000 to 11 024 tons in 2005. Fishing vessels from other nations took 717, 616, 5 572, 1 563, 2 259, 2 147 and 1 840 tons of shrimp in each respective year. Table 1 provides a break down of catches by nation and year. Figure 1 indicates catches and TAC since 1992.

Canadian Multi-species Bottom Trawl Research Survey Trends

Spring and autumn multi-species research surveys, using a Campelen 1800 shrimp trawl, have been conducted onboard the Canadian Coast Guard vessels *Wilfred Templeman*, *Teleost* and *Alfred Needler* since 1995. 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; 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. Stratified abundance and biomass indices were estimated via areal expansion using programs based upon Cochran (1997) and written in SAS (D.C. Orr, unpublished).

Due to operational difficulties it was not possible to survey all of the strata within NAFO Div. 3LNO during autumn 2004 (Brodie, 2005). The deepwater strata (deeper than 731 m) within Div. 3LNO as well as several shallow water strata within Div. 3L were not surveyed. 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 (Table 2). Therefore this paper focuses upon the Div. 3NO indices and the impact of strata missed within Div. 3L. Strata that were missed in Div. 3L (autumn 2004) are highlighted in Table 2 and Fig. 3.

Please note that all strata, within the NRA, that contained significant quantities of northern shrimp, in previous spring and autumn surveys, were surveyed during autumn 2004.

Analyses of the autumn 1995-2003 survey data indicate that the 3L strata missed in 2004 (93-549 m) are important in determining the biomass indices. Typically these strata account for 25-61% of the Div. 3L biomass (Table 2). Figures 4 and 5 confirm the importance of these strata and that catches, within these strata, vary both seasonally and annually. For these reasons, it was not appropriate to use a multiplicative model to estimate Div. 3L biomass and abundance indices for the missing strata from the autumn 2004 survey. However, analyses conducted on strata that had been consistently fished each autumn since 1995 produced an estimate of 96 926 tons (95% C.I. = ± 21,744 tons) of northern shrimp, the second highest value, for this partial index, within this time series. It should be noted that the confidence intervals of the biomass estimates from strata completed in the autumn 2004 are relatively tight, indicating relatively low variances between catches. Further, the lower confidence limit of the partial autumn 2004 survey is above the lower confidence limits from the previous four autumn surveys (i.e. from the total Div. 3L indices). The inclusion of additional strata in the overall biomass index would result in the index increasing or staying the same. Therefore one may conclude that the biomass index from the autumn of 2004 was at least as high as it was in the previous four years.

Analyses from the spring 2005 survey indicated that the Div. 3LNO trawlable biomass was 155 627 tons (95% C.I. = ± 12 534 tons), the third highest value in the time series. In general, the spring indices are thought to be less precise because the 95% confidence intervals are sometimes broad with negative lower confidence interval values (Tables 4 and 5; Fig. 6), although this was not the case in 2005.

Div. 3N generally accounted for less than 10% of the total Div. 3LNO biomass (and less than 3% since 1998) while Div. 3O accounted for less than 1% of the Div. 3LNO biomass (Table 5). Autumn 2004 biomass indices for 3NO were similar to indices from previous years.

Conclusions

Although it was not appropriate to estimate the autumn 2004 biomass index within the entire of NAFO Div. 3LNO, it was possible to estimate biomass within NAFO Div. 3NO and the strata that had been consistently surveyed in Div. 3L. Biomass indices within Div. 3NO were similar to previous year estimates. The autumn 2004 biomass index, within consistently sampled Div. 3L strata, was 96 926 tons, the second highest value in this time series. The spring 2005 biomass index was 155 627 tons, the third highest in the time series; however, the spring biomass indices are thought to be less precise. Based on the information available, no change is proposed for the Scientific Council advice for a TAC of 22 000 tons in 2006.

Acknowledgements

We would like to thank Mr. Gus Cossitt for producing Fig. 3, which indicates the Div. 3L strata missed during the Canadian autumn 2004 research survey.

References

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NAFO 2004. Scientific Council Meeting, October 26 - November 4, 2004. Appendix III. Management advice and responses to special requests.

TABLE 1. Annual nominal catches by country of northern shrimp (*Pandalus borealis*) caught in NAFO Div. 3L.

Country	1999	2000	2001	2002	2003	2004	2005	2006
Canada	78[1]	4,382[1]	5,129[2]	5,414[2]	10,008[2]	10,613[2]	11,024[2]	
Cuba				70[3]	146[1]	145[1]	136[1]	
Estonia		64[1]	2,264[4]	450[5]	152[1]	87[1]		
European Union					117[1]	159[1]	475[3]	
Faroe Islands	706[1]	42[1]	2,052[4]	620[5]	25	614[1]	609[3]	
France (SPM)		67[1]	67[1]	36[3]	144[1]		27[3]	
Greenland		34[1]			672[8]	294[1]	312[3]	
Iceland		99[1]	55[7]	55[7]	133[7]	105[7]		
Latvia		64[1]	67[1]	59[3]	144[1]	105[1]		
Lithuania		67[1]	51[3]	67[3]	142[1]	62[1]		
Norway		77[1]	78[6]	70[6]	145[9]	148[1]	144[3]	
Poland		40[1]	54[1]		145[1]	144[1]		
Portugal			61[5]					
Russia		67[1]	67[1]	67[3]				
Spain	11[1]	40[1]	699[4]		151[1]	140[1]		
Ukraine			57[1]		144[1]	144[1]		
USA				69[3]	144[1]		137[3]	
GRAND TOTAL	795	5,043	10,701	6,977	12,412	12,760	12,864	
TAC (tons)		6,000	6,000	6,000	13,000	13,000	13,000	22,000[10]

Sources:

1 NAFO STATLANT 21A
2 Canadian 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 TAC recommended by Scientific Council during November 2004.

Table 2. Biomass estimates (tons) of northern shrimp (*Pandalus borealis*) from Canadian fall surveys in Div. 3L using a Campelen trawl during 1995-2004. Light shading indicates strata not fished in 2004. The inshore strata were not consistently sampled over the years therefore this table includes only offshore strata. (stand. 15 min. tows)

Depth Range (m)	Area	Stratum	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
57 - 92	2071	350	0	0	1	3	1	1	2	31	38	4
	1780	363	0	1	1	2	0	7	19	18	622	1
	1121	371	0	0	1	0	0	7	5	10	23	0
	2460	372	0	3	12	6	1	7	7	106	166	8
	1120	384	0	2	1	1	2	12	5	489	38	6
	465	785	.	.	.	.	.	.	.	.	.	.
93 - 183	1519	328	32	57	92	15	41	12	14	28	73	38
	1574	341	0	81	41	4	18	27	21	52	58	37
	585	342	0	1	0	25	4	444	4	35	48	1
	525	343	0	1	1	5	1	5	4	5	4	19
	2120	348	4	18	20	56	291	361	435	675	195	5,309
	2114	349	0	3	6	16	12	30	40	466	298	37
	2817	364	1	3	44	14	5	120	190	316	92	26
	1041	365	1	3	105	179	63	.	3,385	3,405	99	.
	1320	370	2	1	57	712	134	84	3,011	129	103	.
	2356	385	1	9	1,471	205	1,274	2,078	4,307	3,629	7,381	5,367
	1481	390	0	0	10	6	12	152	2,498	3,520	7,928	1,330
184 - 274	1582	344	8	29	104	2,858	5,068	3,192	1,971	7,549	2,084	14,774
	983	347	21	45	25	4,850	1,547	7,372	10,450	8,516	1,743	21,775
	1394	366	674	560	11,878	5,425	7,673	24,193	25,316	27,047	22,959	.
	961	369	23	182	1,843	6,319	3,939	3,353	10,842	6,694	21,994	.
	983	386	18	304	9,299	5,981	7,884	6,161	15,245	25,131	22,962	.
	821	389	42	2,007	1,630	6,917	10,065	25,088	32,443	34,321	17,502	11,248
	282	391	0	391	236	166	246	3,643	353	106	7,838	2,312
	164	795	.	.	.	.	.	.	.	.	.	.
	72	789	.	.	.	.	.	.	.	.	.	.
	227	791	.	.	.	.	.	.	.	.	.	.
	100	798	.	.	.	.	.	.	.	.	.	.
275 - 366	1432	345	723	2,030	5,976	9,954	4,361	18,288	17,904	31,885	16,945	20,045
	865	346	1,802	7,069	5,608	3,510	5,328	6,251	18,983	35,886	29,796	11,056
	334	368	77	1,232	483	358	101	27	16,985	457	10,162	.
	718	387	1,199	2,393	4,258	7,197	3,908	12,013	43,798	11,890	44,725	.
	361	388	363	1,599	2,117	1,485	570	4,326	13,612	7,204	3,747	.
	145	392	210	324	73	187	123	387	320	44	881	906
	175	796	.	.	.	.	.	.	.	.	.	.
	81	800	.	.	.	.	.	.	.	.	.	.
367 - 549	186	729	0	3	2	0	51	1	603	0	15	1
	216	731	0	.	16	11	14	112	92	772	0	1,496
	468	733	8	212	170	12	66	0	243	4	0	262
	272	735	134	2	166	2	57	119	8	12	147	.
	50	792	.	.	.	.	.	.	.	.	.	.
550 - 731	170	730	0	1	0	0	0	0	1	0	0	0
	231	732	12	0	0	0	1	0	2	9	0	866
	228	734	0	0	1	0	0	0	1	9	0	.
	175	736	1	0	8	2	2	27	13	0	18	.
732 - 914	227	737	0	0	0	0	0	1	0	0	0	.
	223	741	.	0	0	0	0	0	0	0	21	.
	348	745	.	0	0	0	0	0	10	0	8	.
	159	748	.	0	0	0	0	1	3	0	1	.
915 -1097	221	738	0	0	0	0	0	0	0	0	0	.
	206	742	.	0	0	0	0	0	0	0	0	.
	392	746	.	0	0	0	0	0	4	0	1	.
	126	749	.	0	0	0	.	0	0	0	0	.
1098 -1280	254	739	.	0	0	0	0	0	0	0	0	.
	211	743	.	0	0	0	0	0	0	0	0	.
	724	747	.	0	0	0	0	0	0	1	0	.
	556	750	.	0	0	0	0	0	0	1	0	.
1281 -1463	264	740	.	0	0	0	0	0	0	0	0	.
	280	744	.	0	0	0	.	0	0	0	0	.
	229	751	.	0	0	0	.	0	0	0	0	.
Biomass estimate			5,358	18,566	45,758	56,485	52,864	117,902	223,149	210,453	220,713	96,926
Upper 95% CL.			7,397	28,893	66,426	76,064	69,804	142,948	369,574	299,083	337,873	118,670
Lower 95% CL.			3,318	8,238	25,090	36,905	35,923	92,855	76,725	121,821	103,549	75,182
% of 3L autumn biomass index within the missing strata			**39.74%**	**25.19%**	**61.39%**	**46.34%**	**44.95%**	**39%**	**53.15%**	**35.53%**	**55.81%**	**???**

Table 3. Biomass estimates (tons) of northern shrimp (*Pandalus borealis*) from Canadian fall surveys in Div. 3L using a Campelen trawl during 1995 - 2004. The analyses below are for strata sampled in all years. (stand. 15 min. tows).

Depth Range (m)	Area	Stratum	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
57 - 92	2071	350	0	0	1	3	1	1	2	31	38	4
	1780	363	0	1	1	2	0	7	19	18	622	1
	1121	371	0	0	1	0	0	7	5	10	23	0
	2460	372	0	3	12	6	1	7	7	106	166	8
	1120	384	0	2	1	1	2	12	5	489	38	6
93 - 183	1519	328	32	57	92	15	41	12	14	28	73	38
	1574	341	0	81	41	4	18	27	21	52	58	37
	585	342	0	1	0	25	4	444	4	35	48	1
	525	343	0	1	1	5	1	5	4	5	4	19
	2120	348	4	18	20	56	291	361	435	675	195	5,309
	2114	349	0	3	6	16	12	30	40	466	298	37
	2817	364	1	3	44	14	5	120	190	316	92	26
	2356	385	1	9	1,471	205	1,274	2,078	4,307	3,629	7,381	5,367
	1481	390	0	0	10	6	12	152	2,498	3,520	7,928	1,330
184 - 274	1582	344	9	29	104	2,858	5,068	3,192	1,971	7,549	2,084	14,774
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	821	389	42	2,007	1,630	6,917	10,065	25,088	32,443	34,321	17,502	11,248
	282	391	0	391	236	166	246	3,643	353	106	7,838	2,312
275 - 366	1432	345	723	2,030	5,976	9,954	4,361	18,288	17,904	31,885	16,945	20,045
	865	346	1,802	7,069	5,608	3,510	5,328	6,251	18,983	35,886	29,796	11,056
	145	392	210	324	73	187	123	387	320	44	881	906
367 - 549	186	729	0	3	2	0	51	1	603	0	15	1
	216	731	0		16	11	14	112	92	772	0	1,496
	468	733	8	212	170	12	66	0	243	4	0	262
550 - 731	170	730	0	1	0	0	0	0	1	0	0	0
	231	732	12	0	0	0	1	0	2	9	0	866
Biomass estimate (t)			2,866	12,290	15,543	28,824	28,534	67,597	90,917	128,472	93,767	96,926
Upper 95% CL			5,227	25,047	20,659	49,547	41,246	92,287	130,537	220,851	130,753	118,670
Lower 95% CL			506	-467	10,427	8,099	15,821	42,907	51,298	36,092	56,778	75,182

Table 4 Northern shrimp stock size estimates in NAFO divisions 3LNO from annual spring Canadian multi-species bottom surveys, 1999 - 2003. Offshore strata only. (standard 15 min. tows)

	Biomass (tons)			Abundance (numbers x 10^{-6})			Survey
Year	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1999	12,564	55,317	98,069	3,178	12,702	22,227	313
2000	-15,869	121,815	259,498	-54,743	25,012	104,768	298
2001	62,359	102,566	142,773	13,417	24,845	36,272	300
2002	121,067	159,491	197,916	28,311	37,512	46,714	300
2003	112,299	193,766	275,233	21,857	46,295	70,732	300
2004	-529,764	110,827	751,418	-97,747	21,696	141,395	296
2005	88,504	155,627	222,751	17,441	29,976	42,510	289

Table 5 NAFO divisions 3LNO *Pandalus borealis* biomass estimates for entire divisions. (Shrimp were collected during the Canadian spring and autumn multi-species surveys using a Campelen 1800 shrimp trawl. (standard 15 min. tows).

Season	Year	Division	Entire Division Biomass estimate (Kg x 1000)	Percent by division
Autumn	1995	3L	5,357	90.48
Autumn	1996	3L	18,566	92.42
Autumn	1997	3L	45,758	99.04
Autumn	1998	3L	56,485	94.28
Autumn	1999	3L	52,863	99.47
Autumn	2000	3L	117,902	99.77
Autumn	2001	3L	223,149	99.62
Autumn	2002	3L	210,451	97.88
Autumn	2003	3L	220,711	98.72
Autumn	2004	3L	???	???
Autumn	1995	3N	533	9.00
Autumn	1996	3N	1,514	7.54
Autumn	1997	3N	427	0.92
Autumn	1998	3N	3,360	5.61
Autumn	1999	3N	272	0.51
Autumn	2000	3N	270	0.23
Autumn	2001	3N	836	0.37
Autumn	2002	3N	4,444	2.07
Autumn	2003	3N	2,785	1.25
Autumn	2004	3N	1,422	???
Autumn	1995	3O	31	0.52
Autumn	1996	3O	9	0.04
Autumn	1997	3O	17	0.04
Autumn	1998	3O	69	0.12
Autumn	1999	3O	9	0.02
Autumn	2000	3O	8	0.01
Autumn	2001	3O	10	0.00
Autumn	2002	3O	113	0.05
Autumn	2003	3O	72	0.03
Autumn	2004	3O	77	???
	all divisions			
Autumn	1995		5,921	
Autumn	1996		20,089	
Autumn	1997		46,202	
Autumn	1998		59,914	
Autumn	1999		53,144	
Autumn	2000		118,180	
Autumn	2001		223,995	
Autumn	2002		215,008	
Autumn	2003		223,568	
Autumn	2004		???	

Season	Year	Division	Entire Division Biomass estimate (Kg x 1000)	Percent by division
Spring	1999	3L	53,934	97.50
Spring	2000	3L	119,521	98.12
Spring	2001	3L	102,493	99.93
Spring	2002	3L	155,061	97.22
Spring	2003	3L	195,121	98.46
Spring	2004	3L	109,590	98.88
Spring	2005	3L	154,970	99.58
Spring	1999	3N	1,349	2.44
Spring	2000	3N	2,248	1.85
Spring	2001	3N	53	0.05
Spring	2002	3N	4,395	2.76
Spring	2003	3N	2,852	1.44
Spring	2004	3N	1,099	0.99
Spring	2005	3N	530	0.34
Spring	1999	3O	34	0.06
Spring	2000	3O	46	0.04
Spring	2001	3O	20	0.02
Spring	2002	3O	35	0.02
Spring	2003	3O	196	0.10
Spring	2004	3O	138	0.12
Spring	2005	3O	127	0.08
	all divisions			
Spring	1999		55,317	
Spring	2000		121,815	
Spring	2001		102,566	
Spring	2002		159,491	
Spring	2003		198,169	
Spring	2004		110,827	
Spring	2005		155,627	

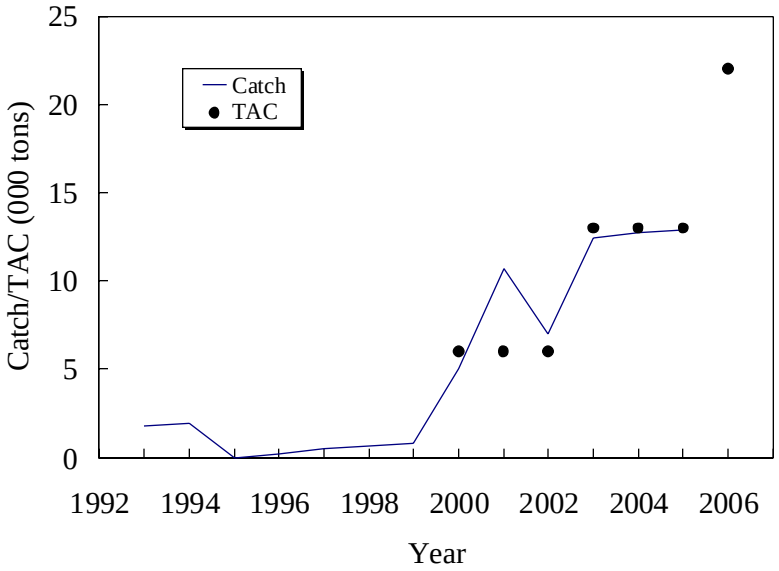

Fig. 1. Trends in NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catch and TAC over the period 1993 – 2005. Please note that the 2006 TAC is the TAC recommended by Scientific Council during November 2004.

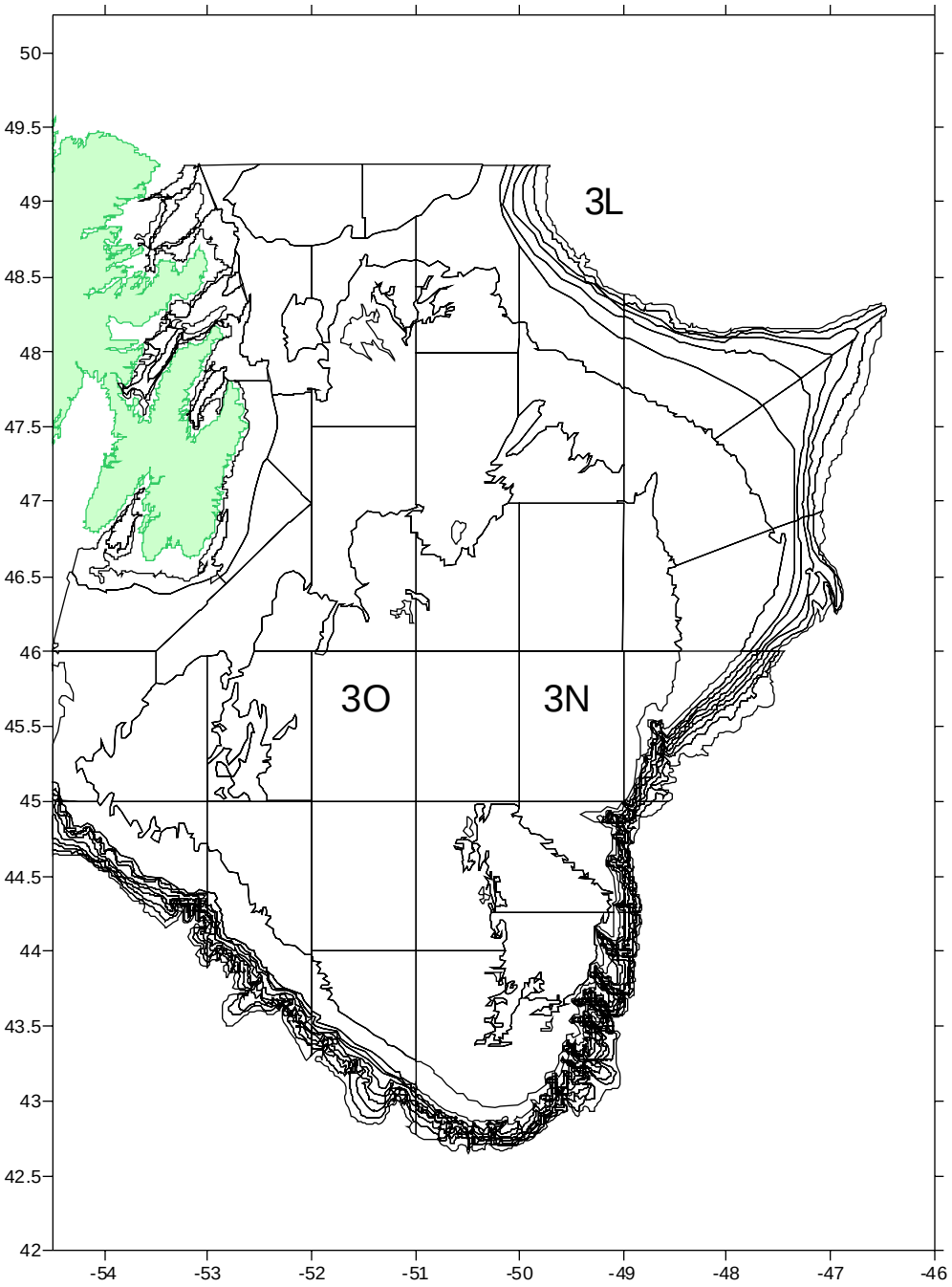

Fig. 2. The NAFO 3LNO stratification scheme used in Canadian research bottom trawl survey set allocation.

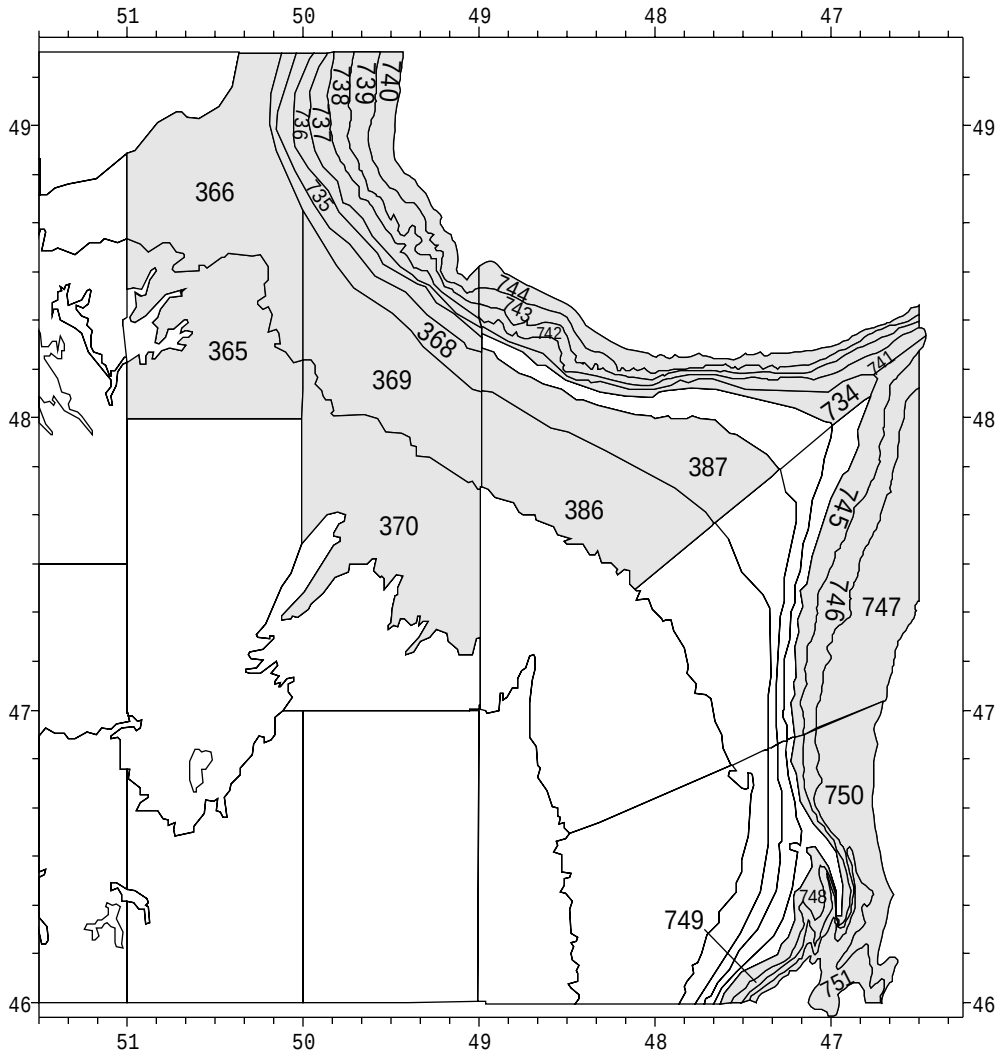

Fig. 3. Strata in Div. 3L that were not surveyed (numbered and shaded area) during autumn 0f 2004.

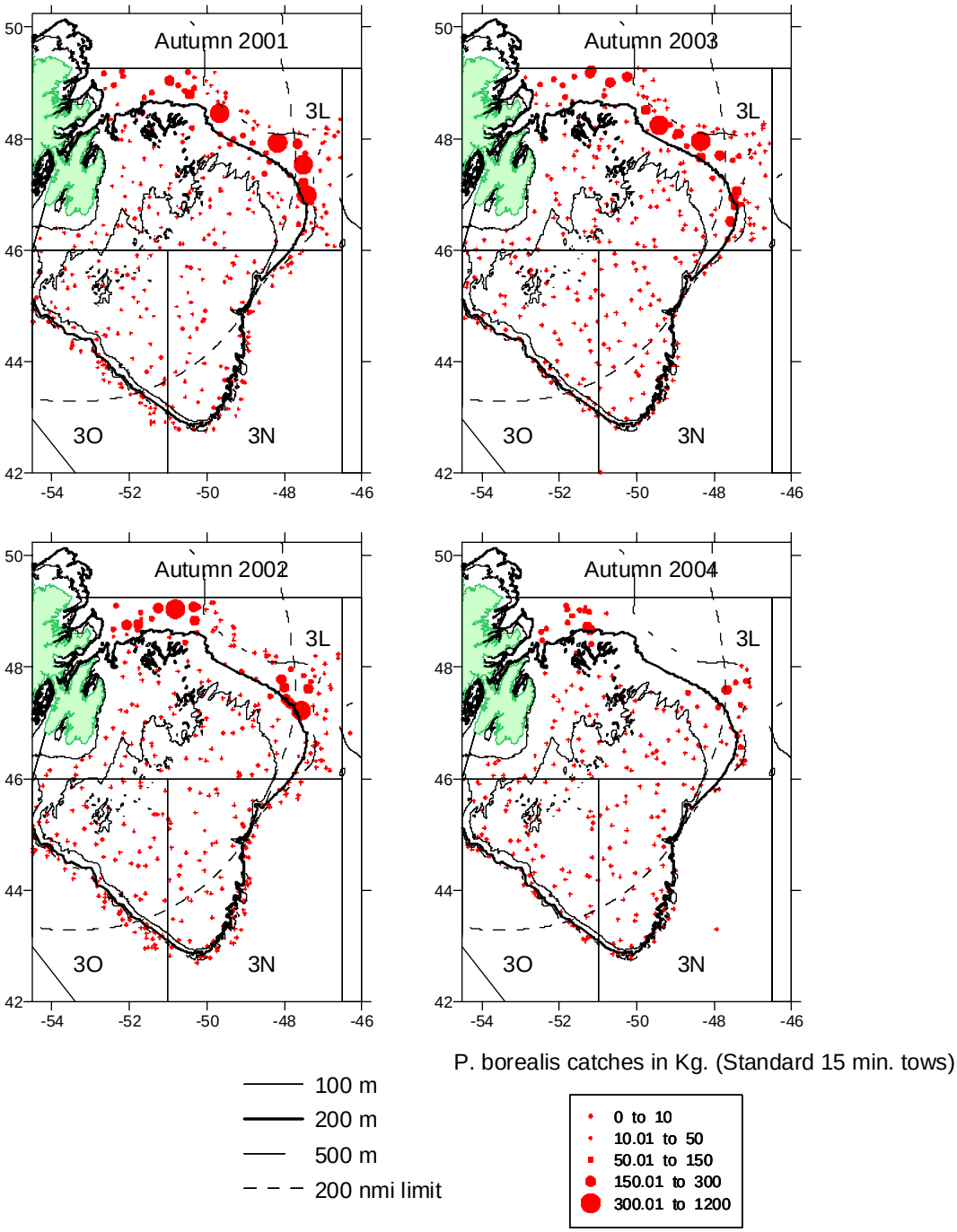

Fig. 4. Distribution of NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catches kg/tow) as obtained from autumn research bottom trawl surveys conducted over the period 2001-2004.

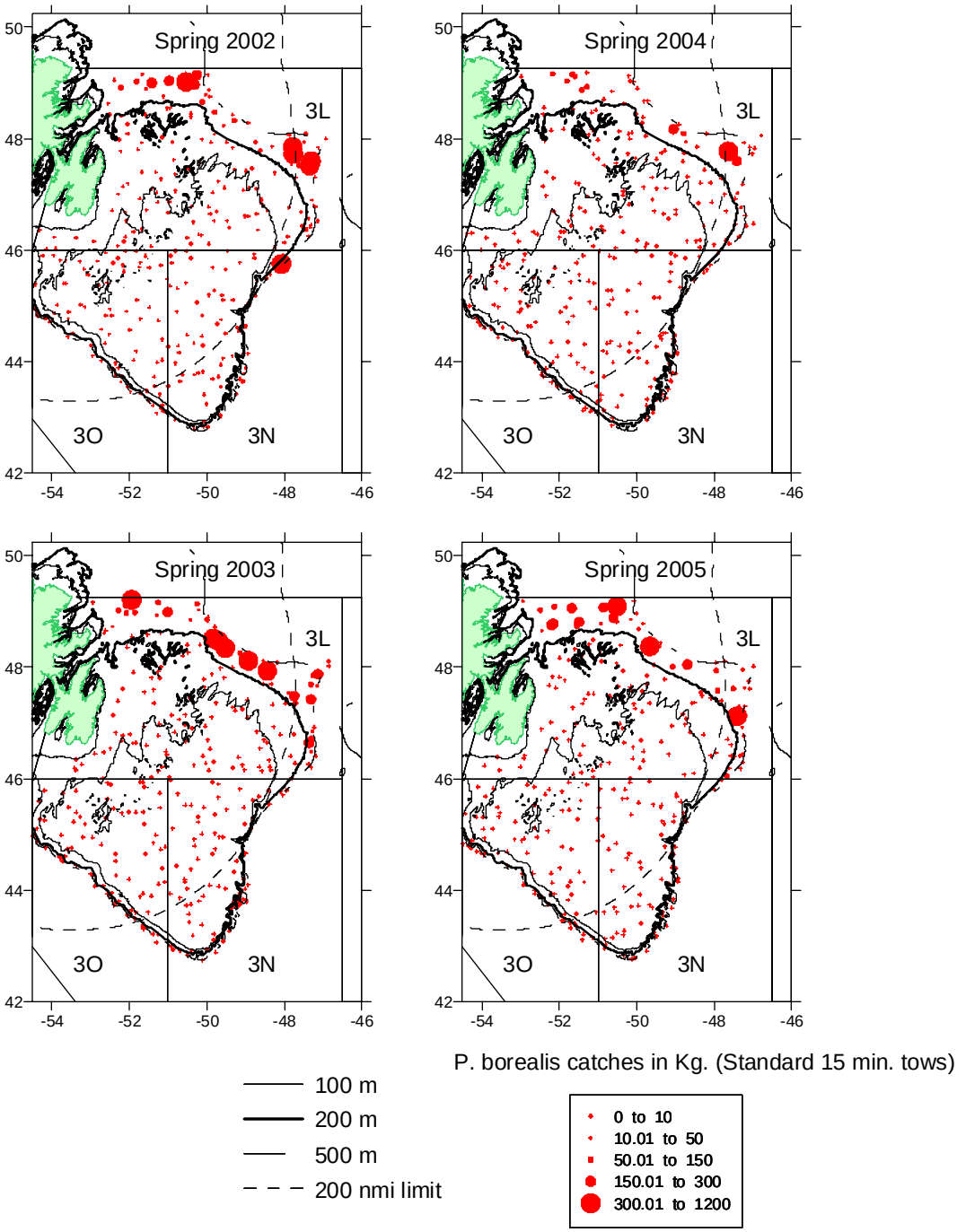

Fig. 5. Distribution of NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catches kg/tow) as obtained form spring research bottom trawl surveys conducted over the period 2001-2004.

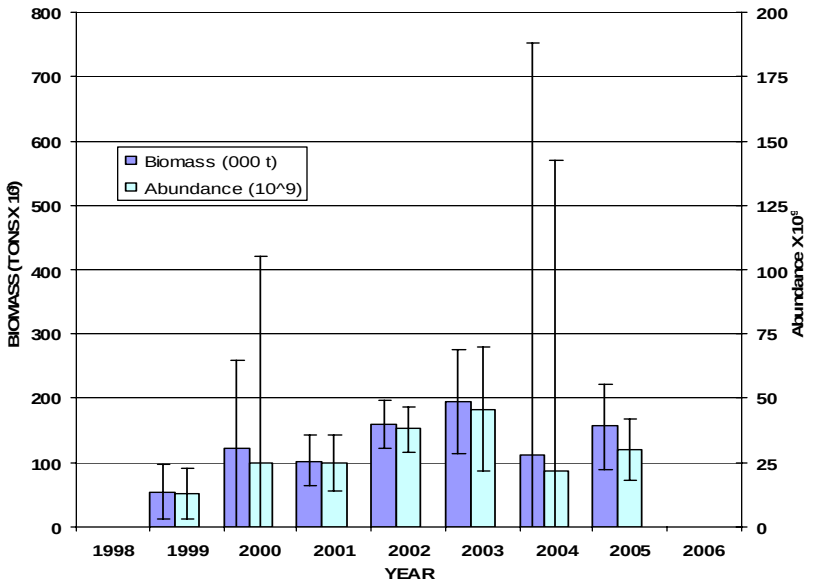

Fig. 6. Spring northern shrimp (*Pandalus borealis*) abundance and biomass estimates within NAFO Div. 3LNO. Data were from Canadian multi-species bottom trawl surveys using a Campelen 1800 trawl. (Standard 15 min. tows.)