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Northern Shrimp (*Pandalus borealis*, Krøyer) from Spanish Bottom Trawl Survey 2009 in NAFO Div. 3LNO

by

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Abstract

The Spanish Institute of Oceanography carried out in 2009 two bottom trawl surveys in the NAFO Regulatory Area in Division 3NO and 3L during the months of June, July and August respectively. The results on Northern shrimp (*Pandalus borealis*) are presented and compared with those from previous surveys from the same series. In 2009 the catch (33 kg.) and estimated biomass (139 t.) confirm the decrease of shrimp importance from 2004 in 3NO. In 2009 the biomass estimated of northern shrimp in 3L Division was 74091 t. showing a drastic decline (50% with respect to 2008) after the upward trend a long the whole period studied.

Catch results from the surveys and data analysis are discussed in this paper.

Introduction

Northern shrimp (*Pandalus borealis* Krøyer, 1883) is a protrandric, circumpolar species, discontinuously distributed in the North Atlantic and of considerable commercial importance. The greatest abundance is being in the Northwest Atlantic at latitudes above 46ºN. The stock of this species in Div. 3LNO, NAFO is distributed along the entire edge of the grand banks, at depths generally ranging from 185 to 550 metres, although historically at least 95.9% of the 3LNO shrimp biomass had been found within Division 3L (Orr *et al*, 2008).

Since 1995, Canadian multi-species stratified random surveys have been used to estimate northern shrimp biomass and abundance indices within NAFO Div. 3LNO. In this series of surveys, Div. 3N accounts for between 0.4 and 8.1% of the total 3LNO biomass. Between 33.0 and 77.4% of the 3N biomass is located beyond the 200 mile limit (Orr *et al*., 2008). The biomass in Division 3O accounts for less than 1% of the biomass in Div. 3LNO and only the 0.34% of the biomass in Div. 3O is beyond the 200 mile limit (Orr *et al*., 2008).

The Vigo Centre of Instituto Español de Oceanografía is conducting research cruises since 1995 in the NAFO Regulatory Area in Div. 3NO beyond the 200 mile exclusive economic zone. A stratified, random, bottom trawl, multi-species research sampling program was carried out to obtain abundance and biomass indices as well as other biological data for the most important commercial species present in the area. In the surveys conducted between 1995 and 2000, the catches of northern shrimp were insignificant. This could be explained by the low efficiency of the fishing gear "pedreira", with this species (Paz *et al*., 1995), used in those years.

Since 2001, the survey was carried out on board R/V "*Vizconde de Eza*" using a Campelen 1800 net (*Walsh et al., 2001*). Despite the improvements incorporated with the new vessel and the use of a Campelen 1800 net, which is highly efficient for this species (*Vazquez, 2002*), total catches in 2001 were poor, i.e., 29 kg.

From 2002 year a significant increase of the catches of northern shrimp was noted in 3NO Division with catches bigger than 300 kg.

Also, since 2003 a new research survey was conducted in Division 3L as an extension of the survey carried out in 3NO (Román *et al.*, 2008). The estimated biomass in 3L Division always was very superior to that estimated in 3NO.

This work presents data on the geographical distribution in the NAFO Regulatory Area (Div. 3LNO), on biomass, length frequencies, age structure and length-weight relationship of catches of northern shrimp on Spanish bottom trawl surveys 2009.

Materials and Methods

The 2009 Spanish bottom trawl surveys were carried out from the 31th of May to 18th of June in 3NO and from 25th of July to 12th of August in 3L, following set guidelines previously established for the series of I.E.O. research surveys (Walsh *et al.*, 2001). These surveys took place in Div. 3NO and 3L, with a total of 109 and 98 valid hauls respectively ranging depths between 40 and 1450 m approximately. Due to operational difficulties it was not possible to prospect all of the strata within NAFO Div. 3NO during spring 2009; the strata deeper (763 and 767) were not surveyed.

Shrimp samples of approximately 1.5 kg were taken to determine length frequencies in hauls where the amount and good condition of the specimens caught permitted to sample them. Males and females were separated with reference to the endopodite of the first pleopod (Rasmussen, 1953). Following this criterion, individuals that were in the middle of a sex change were considered as females. The females were differentiated into mature and immature, following the sternal spines criteria (McCray, 1971). Ovigerous females were considered as an independent group not included within the mature females.

Individuals were measured onboard by noting the distance from the base of the eye to the posterior mid dorsal point of the carapace -CL- to the lower 0.5 mm length-classes (Shumway *et al*., 1985). Such measurements were made to the lower half millimetre using electronic callipers.

Furthermore, in 2008 survey some samples were frozen onboard to determine the length-weight relationship in the laboratory. 445 and 4114 individuals were selected in 3NO and 3L Divisions respectively, dried and weighed with a precision of 0.1g to calculate the length-weight relationship in each Division.

Results and Discussion

The Table 1 shows the catches, biomass and standard errors estimated by swept area method of northern shrimp from the multi-species surveys, carried out by IEO Vigo from 1995-2009 in the NAFO Div. 3NO and from 2003-2009 in Division 3L. In the summer of 2005 the research survey could not be carried out in Division 3L. From the year 2002 an abrupt increase with respect to earlier years occurred in 3NO Division, both in terms of catch and biomass (Diaz *et al*., 2002). These initial data were considered with caution due to the fact that, until 2001, the "Pedreira" gear used as a sampler (Paz *et al*., 1995) was not efficient for catching shrimp. However, although in 2001, the gear "type Pedreira" was changed for a new type "Campelen 1800" (Walsh *et al*., 2001) with high efficiency for catching this species (Vazquez, 2002), the catches and biomass estimated stayed at low levels.

After 2002 year, the increase in northern shrimp catch in 3NO was confirmed, in terms of the period 1995-2001 although in the last four years both the catches and estimated biomasses of shrimp have decreased markedly with levels of biomass in 2009 around 139 t. (Figure 1).

Unlike 3NO, the estimated biomass in Division 3L since the beginning of the new survey in 2003 showed a general upward trend from 63647 t. in 2003 to 149265 t. in 2008. This trend seems to change in 2009 with the strong decline of the biomass estimated (74091 t., about 50% with respect to 2008).

The distribution of northern shrimp catches in the Spanish trawl survey 2009 is shown in Figure 2. As in previous years the main catches were located at medium depths from 100 to 200 fathoms (179-386 m.) in Div. 3L. The residual catches in 3NO were mainly located to the Northeast of Div. 3N, in latitudes higher than 45ºN.

Tables 2 and 3 show the shrimp biomass by depth strata from 1995 to 2009 surveys in Divisions 3NO and from 2003 to 2009 in 3L. Although it is considered that the shrimp in Div. 3LNO is distributed along the entire edge of the grand banks, at depths generally ranging from 100 to 300 fathoms (180-550 m.), the depth of the bulk of biomass present differences in 3L and 3NO Divisions. While in 3L Division practically the total of the biomass (>95%) were produced all years in depths lower than 200 ft., in 3NO the percentage of the estimated biomass in depths lower than 200 ft. varied along the years, showing a deeper distribution in 2004 and 2005 where the percentage of the shrimp catches in depths bigger than 200 ft. was around 74 and 66 % respectively.

The length distribution by sex estimated in the 3NO and 3L are presented in table 4 and figure 3. Although the range of their length distributions and sex ratio were similar in both Divisions, there were differences between them in some of the modal groups identified. Although the survey in Div. 3NO was carried out one month earlier than in Div. 3L, the length at the first mode identified in 3NO at 17.5 mm was higher than in 3L (around 16 mm.). In the same way the other two prominent modes in 3NO corresponding with lengths at 21.5 and 23 mm. were higher than their corresponding modes in 3L (around 20 and 22.5 mm.).

The MIX modal size analysis programme was used with the length distribution by sex estimated in 3L Divisions (Table 5). From the cited analysis the males presented three modes at 13, 16.4 and 19.9 mm. corresponding with ages 2, 3 and 4 respectively. The sex change occurrs at age 4. The females showed several modes at 19.7, 22.2, 24.2 and 26.2 mm (ages 4, 5, 6 and 7 respectively).

The Table 6 shows the length-weight relationship estimated in 2009 surveys by sex and maturity stage as well the parameters of the relationship, number of specimens sampled and determination coefficient R^2.

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Table 1.- Northern shrimp biomass estimated by swept area (t.), standard error and catches (kg.) from Spanish bottom trawl survey in NAFO Div. 3NO, 1995-2008 and 3L 2003-2009.

3NO

Year	Biomass		Catch
	tons	Std. err.	(kg.)
1995[1]	14	13	5
1996[1]	18	17	2
1997[1]	1	1	0
1998[1]	23	17	5
1999[1]	81	36	13
2000[1]	26	9	6
2001[2]	178	72	29
2002[2]	2043	814	408
2003[2]	1618	716	325
2004[2]	2654	1693	550
2005[2]	1627	590	368
2006[2]	1274	352	278
2007[2]	401	285	71
2008[2]	144	98	24
2009[2]	139	111	33

3L

Year	Biomass		Catch
	tons	Std. err	(kg.)
1995[1]			
1996[1]			
1997[1]			
1998[1]			
1999[1]			
2000[1]			
2001[2]			
2002[2]			
2003[2]	63647	20105	5836
2004[2]	94270	40332	5093
2005		Not surveyed	
2006[2]	125850	12690	17805
2007[2]	113402	13445	18098
2008[2]	149265	48489	23720
2009[2]	74091	37999	12173

[1] Pedreira codend 35 mm. mesh size.
[2] Campelen codend 20 mm. mesh size.

Table 2.- Northern shrimp biomass (kg.) by strata from Spanish bottom trawl survey 2001-2009 in NAFO Div. 3NO.

Division 3NO

Stratum	Area miles^2	Depth range ft.	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
375	271	0-30	0	0		0	0	0	3453	0	25	0	0	1989	0	0	0
376	1334	0-30	0	0		0	0	0	1270	0	0	0	341	4203	0	0	0
353	269	31-50	0	0		0	0	0	79	0	48	0	0	0	126	0	16
360	2783	31-50	0	0		0	0	0	26423	1457	3470	24	0	0	445	0	110
374	214	31-50	0	0		0	0	0	178	0	0	0	0	0	62	0	0
354	246	51-100	0	0		0	0	0	87612	0	292	6917	0	0	14	0	0
359	421	51-100	0	0		0	1389	0	6348	847	1309	43	41	22	98	42	0
377	100	51-100	0	0		0	208	44	0	2020	751	1471	3742	3704	83	60	40
382	343	51-100		0		0	213	206		112695	302	297	825	944	191	4131	0
355	74	101-150		0		0	0	0	15170	147	7635	6146	6183	9179	262	204	0
358	225	101-150	0	0		0	30129	0	717	3261	3900	10289	32548	258	2357	2902	0
378	139	101-150	0	0		8968	10998	1196	17004	680353	11429	772	3985	10066	1357	481	73
381	144	101-150		0		63	11205	122		84984	20648	225280	1486	75176	303300	114294	466
356	47	151-200		0		0	0	0	137	0	1337	12937	8046	2683	213	635	39
357	164	151-200	0	18097		0	0	0	606	16414	425145	163606	38796	114178	9307	1249	959
379	106	151-200	0	0	720	0	135	0	12511	70342	254080	7709	329867	116970	12146	2238	5079
380	96	151-200		0		1024	9346	10240		1000960	698502	258603	120866	607392	6488	11379	125767
721	65	201-300		0		0	0	0	2889	3282	1112	852	256	3054	0	257	318
723	155	201-300		0		0	16872	0	0	12667	92831	44044	3333	53799	14615	90	0
725	105	201-300	14315	0		0	0	0	271	527	91803	1814540	748369	206794	47133	578	239
727	96	201-300		0		13213	0	11429		28660	2119	98477	326841	62635	1248	3172	179
722	84	301-400		0		0	37	734	2890	60	156	0	36	0	0	0	0
724	124	301-400	0	0		0	0	0	0	55	628	58	165	53	213	0	0
726	72	301-400	0	0		0	0	0	0	7	54	2048	0	406	170	0	5351
728	78	301-400		0		0	0	1671		7280	0	0	86	135	0	0	41
752	131	401-500		0		0	0	0		86	0	49	222	58	309	0	143
756	101	401-500		0		0	0	0	0	0	46	42	869	84	27	84	391
760	154	401-500		0		0	0	0	0	0	283	49	0	0	590	0	0
764	100	401-500		0		0	0	0	42	0	0	0	0	0	0	0	0
753	138	501-600		0		0	0	0		0	0	0	0	166	0	0	0
757	102	501-600		0		0	0	0		204	0	0	27	0	67	0	0
761	171	501-600		0		0	0	0	0	0	0	0	0	0	99	0	0
765	124	501-600		0		0	0	0	0	37	0	0	0	0	0	0	0
754	180	601-700				0	0	0		0	0	0	0	0	0	207	0
758	99	601-700				0	0	94		16302	0	19	88	0	0	0	0
762	212	601-700				0	0	0	0	85	0	0	0	0		0	0
766	144	601-700				0	0	0		19	58	0	0	0		0	0
755	385	701-800				0	0	89		0	174	0	68	0	0	1839	0
759	127	701-800				0	0	0		17	0	48	0	0		0	0
763	261	701-800				0	0	0		0	0	0	0	0		0	
767	158	701-800				0	0	0		0	0	0	0	0		0	
Biomass (t)			14	18	1	23	81	26	178	2043	1618	2654	1627	1274	401	144	139
Std. Error			13	17	1	17	36	9	72	814	716	1693	590	352	285	98	111
Biomass % < 200 fth			0.0%	100.5%	72.0%	43.7%	78.5%	45.4%	96.4%	96.6%	88.3%	26.2%	33.6%	74.3%	83.9%	95.6%	95.3%

Table 3.- Northern shrimp biomass (kg.) by strata from Spanish bottom trawl survey 2003-2009 in NAFO Div. 3L.

Division 3L

Stratum	Area miles^2	Depth range ft.	2003	2004	2005	2006	2007	2008	2009
385	2356	51-100	420	175		2485867	2416545	8265541	140724
390	1481	51-100	1014	3780		2577958	5404325	317330	37466118
389	821	101-150	14397492	41654297		53639329	49120205	74404070	25997291
391	282	101-150	1116135	1299793		3712072	12397477	24948041	28071
387	718	151-200	17618619	21721973		29967360	11782827	14287154	6473372
388	361	151-200	25169595	24779540		32585066	26954928	21602795	2348269
392	145	151-200	2821419	1866379		193967	1199955	3675300	1564098
729	186	201-300	20371	1465049		88481	172095	16126	11533
731	216	201-300	2449416	1467221		177357	666240	1501056	54100
733	468	201-300		4077		390052	3281339	240647	6718
730	170	301-400	0	876		1485	76	32	20
732	231	301-400	34907	5643		14535	4723	1905	226
734	228	301-400		408		10554	136	2144	69
741	223	401-500	0	56		1379	22	486	0
745	348	401-500	17642	0		1699	186	1950	0
748	159	401-500	292	696		366	499	66	0
742	206	501-600	0	0		462	0	0	0
746	392	501-600	0	0		134	0	74	70
749	126	501-600	0	23		99	0	0	0
743	211	601-700		0		1020	0	23	0
747	724	601-700		0		147	0	41	201
750	556	601-700		0		58	0	132	294
744	280	701-800		0		185	0	0	0
751	229	701-800				0	0	0	0
Biomass (t)			63647	94270		125850	113402	149265	74091
Std. Error			20105	40332		12690	13445	48489	37999
Biomass % < 200 fth			96.0%	96.9%		99.5%	96.4%	98.8%	99.9%

Table 4.- Northern shrimp size distribution (‘000) by sex from Spanish bottom trawl survey 2009 in NAFO Div. 3NO an 3L.

3NO			
CL (mm)	**Males**	**Females**	**Total**
8			
8.5			
9			
9.5			
10			
10.5			
11	173		173
11.5	259		259
12	259		259
12.5	86		86
13	8		8
13.5	94		94
14	173		173
14.5	94		94
15	0		0
15.5	173		173
16	139		139
16.5	275		275
17	180		180
17.5	879		879
18	691		691
18.5	353		353
19	793	45	838
19.5	887		887
20	1523	8	1530
20.5	1185	259	1444
21	1394	564	1959
21.5	373	2371	2744
22	182	2160	2342
22.5	94	1946	2040
23		3059	3059
23.5		1025	1025
24		697	697
24.5		547	547
25		288	288
25.5		248	248
26		156	156
26.5		115	115
27		55	55
27.5		17	17
28		17	17
28.5		9	9
29		18	18
29.5			
30			
30.5			
31			
31.5			
Total	10268	13605	23873
	43%	57%	

3L			
CL (mm)	**Males**	**Females**	**Total**
8			
8.5			
9			
9.5			
10	15		15
10.5	5876		5876
11	13004		13004
11.5	35288	8	35296
12	54277	21	54297
12.5	79007	51	79058
13	95835	5865	101700
13.5	27895	1215	29110
14	61216	342	61557
14.5	50632	329	50961
15	52483	363	52847
15.5	152807	11472	164279
16	224574	17480	242054
16.5	179313	9786	189099
17	225114	23151	248265
17.5	299289	23406	322695
18	373764	45464	419228
18.5	453553	46637	500191
19	617047	50320	667368
19.5	550212	194280	744492
20	723754	168033	891786
20.5	487150	349034	836183
21	444480	340892	785372
21.5	208132	661238	869370
22	160899	848176	1009075
22.5	113877	853459	967336
23	37676	709227	746903
23.5	7661	766747	774408
24	2545	570757	573301
24.5		646501	646501
25		459739	459739
25.5		194710	194710
26		215603	215603
26.5		170276	170276
27		61096	61096
27.5		64717	64717
28		32208	32208
28.5		1517	1517
29		5692	5692
29.5			
30			
30.5			
31			
31.5			
Total	5737374	7549812	13287187
	43%	57%	

Table 5. Results of the modal analysis (MIX) by sex and maturity stage Spanish bottom trawl survey 2009 in NAFO Div. 3L.

	3NO					*3L*			
	Males		***Females***			***Males***		***Females***	
Age	***Prop.***	***St. Dev.***	***Prop.***	***St. Dev.***		***Prop.***	***St. Dev.***	***Prop.***	***St. Dev.***
1									
2	0.10	0.0030				0.07	0.0001		
3	0.24	0.0049				0.14	0.0004	0.01	0.0000
4	0.65	0.0053				0.80	0.0004	0.07	0.0002
5			0.92	0.0043				0.45	0.0007
6			0.08	0.0041				0.39	0.0006
7			0.00	0.0008				0.09	0.0005
Age	***Mean CL***	***St. Dev.***	***Mean CL***	***St. Dev.***		***Mean CL***	***St. Dev.***	***Mean CL***	***St. Dev.***
1									
2	12.55	0.0179				12.99	0.0024		
3	17.53	0.0209				16.44	0.0030	16.45	0.0034
4	20.45	0.0129				19.87	0.0013	19.74	0.0030
5			22.72	0.0115				22.26	0.0021
6			25.56	0.0788				24.20	0.0036
7			29.54	0.9624				26.22	0.0047
Age	***Sigma***	***St. Dev.***	***Sigma***	***St. Dev.***		***Sigma***	***St. Dev.***	***Sigma***	***St. Dev.***
1									
2	0.56	Fixed CV				0.92	0.0018		
3	0.79	Fixed CV				0.91	0.0026	0.74	Fixed CV
4	0.92	Fixed CV				1.41	0.0009	0.89	Fixed CV
5			1.02	Fixed CV				1.00	Fixed CV
6			1.15	Fixed CV				1.09	Fixed CV
7			1.33	Fixed CV				1.18	Fixed CV

Table 6.-Northern shrimp length-weight relationship by sex, maturity stage and all combined from Spanish bottom trawl survey 2009 in NAFO Div. 3NO and 3L

Division 3NO

	a	b	R^2	N
Males	0.00112	2.79017	0.96255	144
Inmature females	0.00180	2.63604	0.71885	199
Mature females	0.00037	3.14178	0.89740	102
All combined	0.00103	2.81836	0.96750	445

Division 3L

	a	b	R^2	N
Males	0.00160	2.64869	0.93115	2103
Inmature females	0.00143	2.69236	0.69299	754
Mature females	0.00135	2.71096	0.75703	1158
Ovigerous females	0.00102	2.82240	0.74250	99
All combined	0.00128	2.72684	0.95524	4114

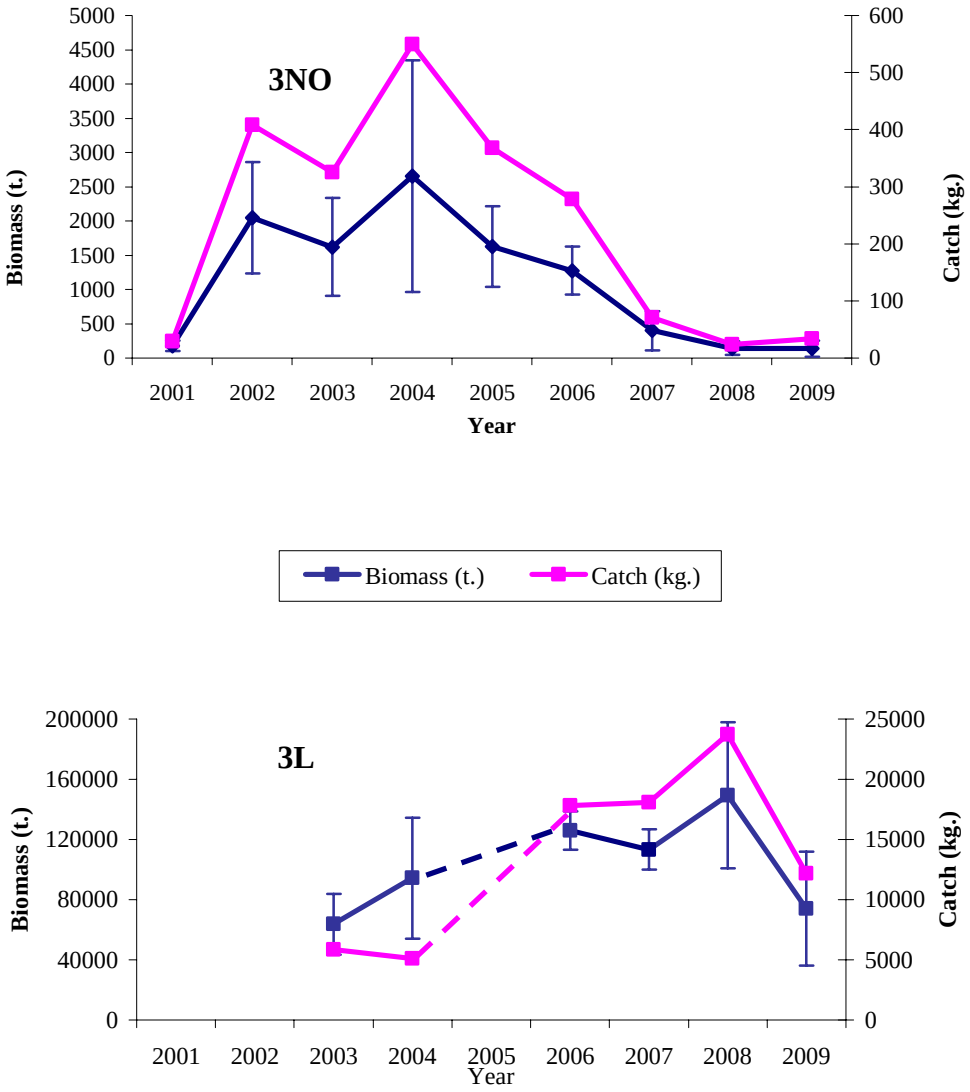

Figure 1.- Northern shrimp biomass (tons) and catch (kg) from Spanish research surveys in NAFO Div. 3NO 2001-2009 and 3L 2003-2009.

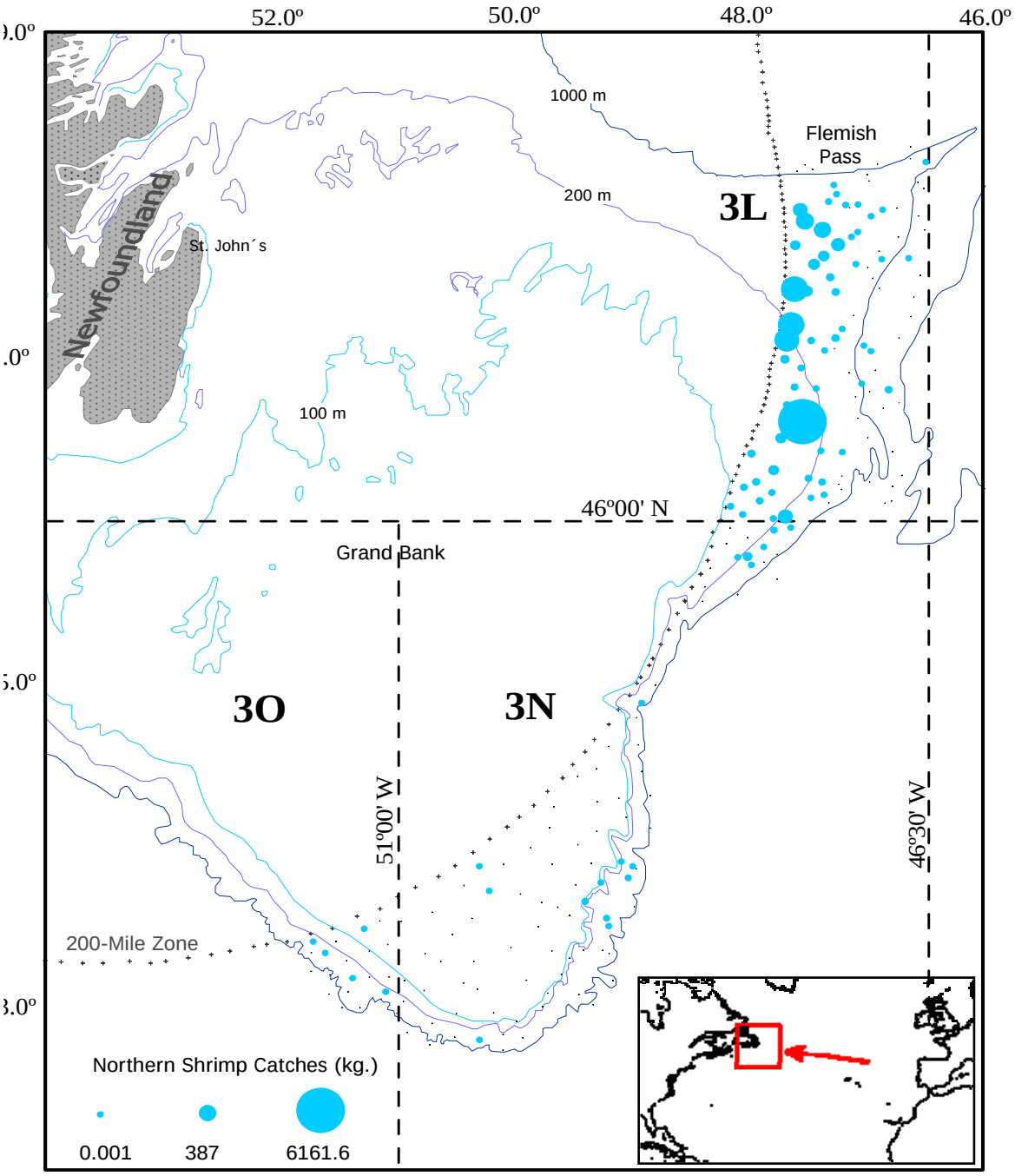

Figure 2.- Geographic distribution of Northern shrimp catches from Spanish bottom trawls surveys 2009.

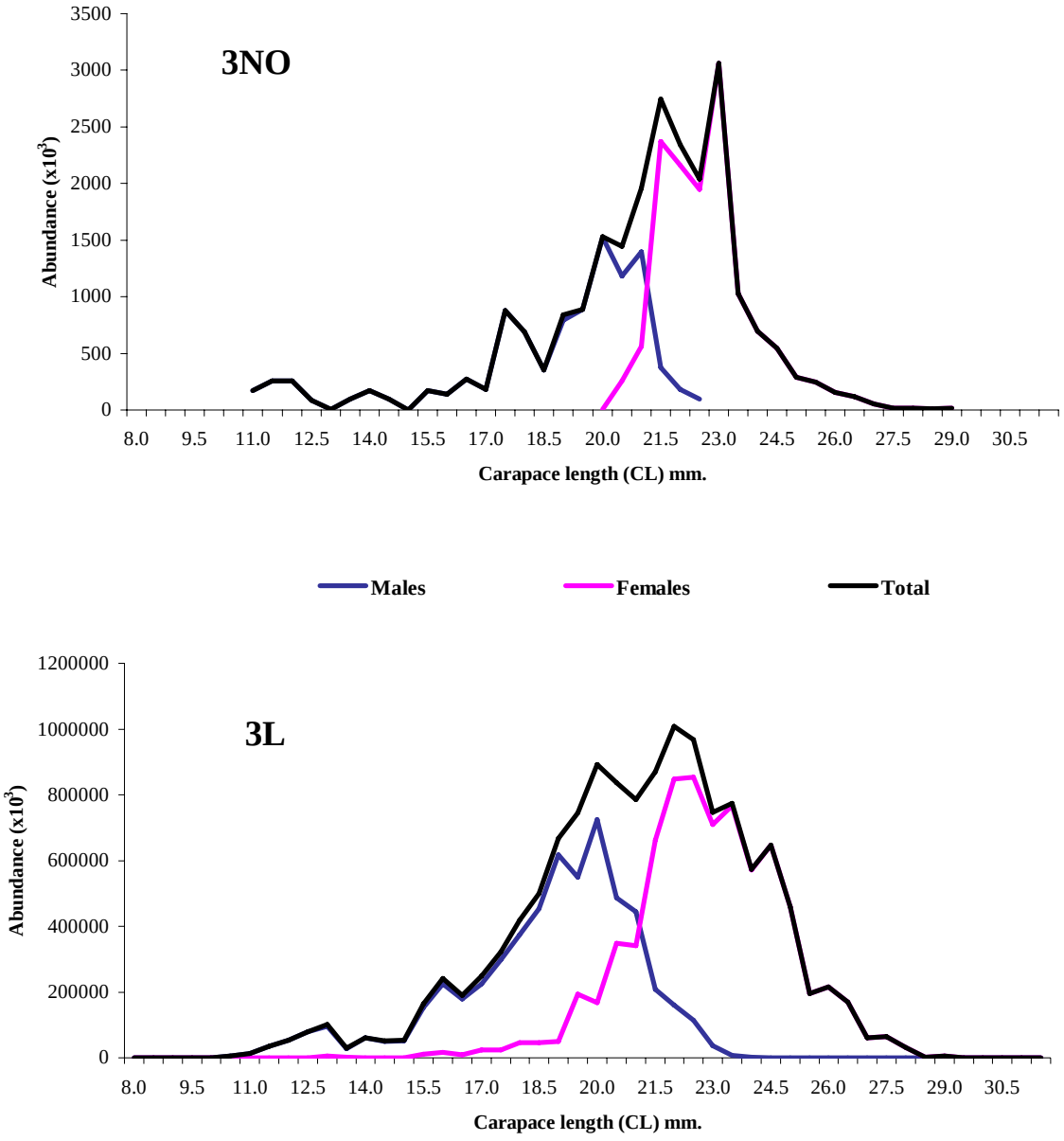

Figure 3.- Northern shrimp size distribution, by sex from Spanish bottom trawl surveys in Div. 3NO and 3L.